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ENCYCLOPÆDIA MEDICA

UNDER THE GENERAL EDITORSHIP OF

CHALMERS WATSON, M.B., F.R.C.P.E.

VOLUME XIII

ULCERATION TO ZINC POISONING

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Definitions.—An *ulcer* may be defined as an open sore or wound in which there are present certain conditions tending to prevent it undergoing the natural process of repair.

The process by which an ulcer is formed, and by which it increases in size—*ulceration*—may be defined as the molecular or cellular death of tissue taking place on a free surface. It is, to all intents and purposes, of the same nature as the process of suppuration (*q.v.*), the only important difference being that while in suppuration the purulent discharge resulting from the death of the tissue elements collects in a closed cavity and forms an abscess, in ulceration it escapes at once on the surface.

Conditions which prevent Healing.—Of the conditions which tend to interfere with the spontaneous healing of an ulcer the most potent is the presence of *pathogenic bacteria*. These organisms not only prevent healing, but by producing irritation and causing destruction of tissue they lead to an actual increase in the size of the sore.

Œdema and *venous congestion* impede healing by interfering with the nutrition of the affected part, and *induration* of the area surrounding an ulcer also prevents healing, as the tissues are unable to contract. *Interference with the nerve-supply* of the tissues, such as occurs, for example, in spinal disease, infantile paralysis, and certain nervous diseases, may also play an important part in delaying repair. In Bright's disease, diabetes, syphilis, and certain other *general constitutional conditions,* the vitiated state of the tissues is an impediment to repair. It goes without saying that unsuitable dressings, ill-fitting appliances, and other *mechanical causes,* may also interfere with the healing of an ulcer.

Clinical Examination of an Ulcer.—In examining an ulcer clinically attention should be directed to the condition of—(1) Its *base or floor,* noting the presence or absence of granulations, and, if present, their disposition, size, colour and vascularity, and whether they are depressed or elevated in relation to the surrounding parts. (2) The *discharge* from the sore should be examined as to its quantity, consistence, colour, composition and odour. (3) The condition of the *edges* is of great importance, and it should be observed whether or not the marginal epithelium is attempting to grow in over the surface; the shape, regularity and thickness of the edges should also be noted, and whether they are undermined or overlapping, everted or depressed. (4) The *surrounding parts* are examined as to whether they are congested, œdematous, inflamed, indurated, or otherwise. (5) The question of *pain* and tenderness in the raw surface or its surroundings should be inquired into. (6) Lastly, the *situation* of the ulcer should be noted, as certain varieties of ulcer tend to occur with greater frequency on some parts of the body than on others; for example, the varicose ulcer on the front of the leg and the perforating ulcer on the foot, and so on.

THE HEALING SORE.—So many varieties of ulcer are met with clinically that it is necessary for purposes of comparison to recognise a type, and this is conveniently found in the *healing sore,* which forms after a portion of skin has been excised aseptically, for example, in the removal of a small cutaneous tumour, or in the operation of skin grafting. After the removal of such a portion of skin the raw surface soon becomes covered with a layer of coagulated blood, fibrin, and lymph, which in the course of a few days is replaced by the growth of granulations. These granulations are of uniform size, pink in colour, and exude a small amount of serous fluid containing a few dead leucocytes. They grow until they reach the level of the surrounding skin, and so fill in the gap with a fine velvety mass of "granulation tissue." The marginal epithelium spreads in over this granulation tissue as a fine pellicle. Towards the inner edge the young epithelium is very thin, of a delicate bluish-white colour and slightly striated; further out it is thicker and paler. The surrounding parts are healthy, or they may show a slight degree of hyperæmia. There is no pain in the sore, and the patient is not feverish. Such a healing sore may be taken as the ideal form of ulcer, and used as a type with which to compare the ulcers seen at the bed-side.

A SEPTIC ULCER.—We may contrast, for example, the characters of an aseptic healing sore with those of one in which septic infection has occurred. As a result of the action of the bacteria the effused blood and serum undergo septic changes, and are converted into pus. The base of the ulcer becomes red and inflamed, and is bathed in thin yellow or grumous pus, with perhaps here and there small sloughs of the superficial layers of tissue. No granulation tissue forms. The discharge is profuse, thin, acrid, and offensive, and consists of pus, broken-down blood-clot, and sloughs. The edges are inflamed, irregular, and ragged, and there is no sign of young epithelium growing in at the margins. On the contrary, the sore may be actually increasing in area by the breaking down of the tissues at the margins. The surrounding parts are also inflamed, hot, red, swollen, and œdematous, and the whole region is painful and tender. The patient's temperature is probably raised, and there are other signs of fever. Between the aseptic healing sore and the septic ulcer here described all transition forms are met with.

Classification of Ulcers.—The chief difficulty in arriving at a satisfactory and useful classification of ulcers is that of finding a basis of classification. Theoretically the best basis would be that of cause, and if this were adopted a classification which would at least be logical might be framed. It would, however, involve abandoning many of the terms now in current use, and the substitution of new names might lead to confusion. The nomenclature is already sufficiently involved. We speak, for example, of the "traumatic," the "septic," and the "varicose" ulcer in relation to the factor which produces or maintains the condition; of the "syphilitic," the "gouty," and the "diabetic" ulcer, according to the underlying constitutional element; and of the "weak," the "inflamed," the "callous," and the "healing" ulcer, according to the condition in which the sore happens to be when seen by the surgeon. It must be confessed that many of these terms are so convenient and descriptive, and are so well established in surgical nomenclature, that it is undesirable to attempt to abolish them. It would appear, therefore, that we must remain content with a clinical arrangement of ulcers,—it cannot be called a classification,—considering a given ulcer from two points of view—firstly, its *cause*, and, secondly, its *present condition*. Such a method of studying ulcers has the practical advantage that it furnishes us with the main indications for treatment. The cause must be removed, and the conditions so modified as to convert the ulcer into an aseptic healing sore.

A. *Arrangement of Ulcers according to their Cause.*—If we consider ulcers from the point of view of their cause we find that they fall into five main groups:—

1. Ulcers due to traumatism.
2. „ „ imperfect circulation.
3. „ „ interference with nerve-supply.
4. „ „ constitutional causes.
5. „ „ malignant disease.

Each of these groups will be found to contain several subdivisions which will be described below. In all varieties the influence of pyogenic bacteria is a most important factor in their causation.

1. *Ulcers due to Traumatism.*—(*a*) An ulcer may be produced by a direct *crush* or *bruise* by which the skin of the part is completely destroyed, or so far devitalised that it forms a suitable soil for bacteria. This is very common on the leg, for example, where the skin has been grazed by a falling object or by a carriage wheel. In the course of a few days the damaged area becomes of a greyish white colour, large blebs form over it, and the skin dies. When the dead skin is thrown off a raw surface is left covered with feeble granulations, and having small, shready sloughs adhering to it.

(*b*) Similarly an ulcer may be the result of a *burn* or *scald* (vol. ii. p. 145), or of exposure to the Röntgen rays.

(*c*) The "*pressure sore*" is another example of an ulcer due to traumatism. It usually occurs over bony prominences such as the malleoli, the condyles of the humerus or femur, the head of the fibula or the base of the fifth metatarsal, as a result of ill-fitting splints or other appliances. While it is most frequently met with in patients who are paralysed, or who suffer from some nervous lesion, such as infantile paralysis or injury of the spinal cord or nerve-trunks, it may also occur in patients with a perfectly healthy nervous system. On removing the splint the skin of the part pressed upon is found to be of a red or pink colour, with a pale grey spot in the centre, which eventually gives way by sloughing, and leaves an ulcer. *Bed-sores* (vol. i. p. 460) are also to a certain extent the result of undue or prolonged pressure.

2. *Ulcers due to Imperfect Circulation.*—Any interference with the *venous return* from a part plays a most important rôle in producing ulceration. One of the most familiar examples of ulceration due to defective venous circulation is the common "leg ulcer," so frequently met with in the out-patient room in hospital practice. This form of ulcer occurs almost invariably on the front and inner aspects of the lower third of the leg, where, according to Hilton, the anastomosis between the superficial and deep veins is less free than elsewhere, with the result that extra stress is thrown upon the surface veins and the nutrition of the skin is thereby interfered with. That the backward pressure of the column of venous blood and the retarded circulation through the veins are important factors in the causation of this variety of ulcer is proved by the fact that healing only takes place if the patient is confined to bed and the limb elevated. So long as he is going about, all methods of treatment are equally futile, whereas improvement is evident at once if he remains recumbent. In a considerable number of cases, but by no means in all, this form of ulcer is associated with the presence of varicose veins, hence it is often spoken of as the *varicose ulcer.*

The actual ulceration is usually determined by some slight injury or irritation which permits of septic infection of the devitalised skin. As dermatitis and eczema are common along the course of varicose veins, the scratching or rubbing of the part is very liable to break the surface and afford a point of entrance for bacteria. In other cases the ulcer is due to the bursting of a small periphlebitic abscess.

When the ulcer is comparatively small and superficial the destructive process frequently spreads to the walls of the subjacent vessels, and leads to profuse and often dangerous bleeding. In large ulcers which have existed for a considerable time the adjacent veins usually become thrombosed, and may even be transformed into fibrous cords, so that hæmorrhage in such cases is not a common complication.

These "leg" or "varicose" ulcers are at first small and superficial, but from want of care, continued standing or walking, or injudicious treatment, they gradually become larger and deeper. They are not infrequently multiple, and this, together with their depth, may lead to their being mistaken for syphilitic ulcers. The base is covered with imperfectly formed, soft, œdematous granulations, which give off a thin, sero-purulent discharge. The edges show no evidence of healing, and are usually somewhat inflamed. The surrounding parts are pigmented and œdematous, and there is as a rule little pain. This variety of ulcer is particularly prone to pass into the condition known as "callous."

Defective arterial supply is less frequently a cause of ulceration than defective venous return. An atheromatous condition of the minute vessels of the skin, especially in peripheral parts of the body, is apt to favour ulceration by diminishing the supply of arterial blood.

In anæmic patients, especially young girls, ulcers are occasionally met with which have many of the characters of those associated with imperfect venous return. They are very slow to heal, and are liable to pass into the condition known as "weak."

3. *Ulcers due to Interference with Nerve-Supply.*—Any interference with the nerve-supply of the superficial tissues predisposes to ulceration. For example, *trophic ulcers* are liable to occur in injuries or diseases of the

spinal cord, in cerebral paralysis, in infantile paralysis, in ascending or peripheral neuritis, or after injuries of nerve-trunks. As undue pressure is usually an associated cause these ulcers are sometimes spoken of as *pressure ulcers.* As examples may be cited the ordinary *pressure bed-sore* (vol. i. p. 460), which in many cases occurs in patients suffering from some nervous lesion, and the sore which results from the pressure of ill-adjusted splints.

The *acute bed-sore* is a very rapidly progressing form of ulceration which occurs in patients who have had the trophic nerve-supply to the skin interfered with.

The perforating ulcer of the foot is a peculiar type of sore which occurs in association with different forms of peripheral neuritis, and with various lesions of the brain and spinal cord, such as general paralysis, locomotor ataxia, or syringomyelia. It also occurs in patients suffering from glycosuria. Perforating ulcer is met with most frequently under the head of the metatarsal bone of the great toe of labouring men over forty years of age. A callosity forms, and suppuration occurs under it, the pus escaping through a small opening in the centre. The process slowly and gradually spreads deeper and deeper, till eventually the bone or joint is reached, and becomes implicated in the destructive process—hence the term "perforating ulcer." Sometimes the flexor tendons are destroyed, and the toe is dorsiflexed by the unopposed extensors. A few red, firm, wart-like granulations cover the base of the ulcer, and the cavity is filled with effete and decomposing epithelium thrown off from the ingrowing margins. The ulcer is often represented by a long, narrow sinus, and its true nature is liable to be overlooked. It is characteristic of perforating ulcer that the raw surface is absolutely insensitive, and the sinus can be probed and handled without giving the patient the least discomfort. The chronic and intractable character of these ulcers is due to the interference with the trophic nerve-supply of the part, and to the fact that the epithelium of the skin grows in and lines the track leading down to the ulcer, and so prevents it closing. Perforating ulcers are sometimes met with on the sides or dorsum of the foot, or even on the hands and on other parts of the body where pressure is but seldom applied. It is to be borne in mind that other ulcers occur in the foot under callosities independently of any nerve lesion. Although very slow to heal they do not show the same tendency to burrow and persist as the perforating ulcer does.

4. *Ulcers due to Constitutional Causes.*—Various constitutional dyscrasiæ favour the production of ulcers by diminishing the power of resistance in the tissues. In some cases the tissue weakness results from the action of a specific pathogenic virus, as in tuberculosis, syphilis, or leprosy; while in others, so far as we at present know, it depends on impurities or deficiencies of the blood, as for example in the ulcers met with in patients suffering from diabetes, Bright's disease, scurvy, and gout.

(*a*) The *tuberculous ulcer* so often seen in the neck, in the vicinity of joints, and over the ribs and sternum, usually results from the bursting of a tuberculous abscess through the skin. The base is soft, pale, and covered with feeble granulations and grey shreddy sloughs. The edges are of a dull blue or purple colour, and they gradually thin out towards their free margins. But the most characteristic feature of the edges of this variety of ulcer is the fact that they are undermined, so that a probe can be passed for some distance between the floor of the ulcer and the thinned-out edges. Devitalised tags of skin often stretch from side to side of the ulcer. The outline of the ulcer is irregular, and small perforations often occur through the skin. A thin, watery discharge containing grey shreds of tubercular débris escapes. Pain is seldom present.

In the disease known as *lupus* (vol. vii. p. 176) we have another form of tuberculous ulceration, resulting from the fusion of several broken-down tuberculous nodules. The resulting raw surface has a base similar in character to the last, but the edges, instead of being undermined, are studded over with small brown nodules which have not yet fused with the main area.

(*b*) The *syphilitic ulcer* is usually formed by the breaking down of a cutaneous or subcutaneous gumma. It is at first covered by a tough, greyish slough, aptly compared to "wash-leather," which slowly separates and leaves a more or less circular, deep, punched-out surface, on which are seen a few feeble, unhealthy granulations and small sloughs. The edges are raised and indurated; and the discharge is thick, glairy, and peculiarly offensive. The parts around the ulcer are congested and of a dark-brown colour. There are usually several such ulcers together, and as they tend to heal at one part while they spread at another, the affected area assumes a serpiginous outline. Syphilitic ulcers may be met with in any part of the body, but are most frequent in the upper part of the leg, especially around the knee-joint in women, and over the ribs and sternum. The cicatrix which results after healing is usually somewhat depressed.

(*c*) The *scorbutic ulcer* occurs in patients suffering from scurvy, and is characterised chiefly by its marked tendency to bleed.

(*d*) In *gouty* patients small ulcers which are exceedingly irritable and painful occur.

5. *Ulcers due to Malignant Disease.*—It is necessary to mention here certain ulcerative conditions which occur in association with malignant disease. In scirrhus of the breast, epithelioma of the tongue or lip, and in sarcoma, for example, the skin or mucous membrane is liable to be invaded and destroyed by the growth which "fungates" and forms an open vascular sore. These are sometimes spoken of as malignant ulcers, but as they are essentially different in their nature from all other forms of ulcers, and call for totally different treatment, it is best to consider them as complications of the particular tumour and tissue in which they are met. The so-called rodent ulcer and the epithelioma of the skin are described elsewhere.

B. *Arrangement of Ulcers according to their Condition.*—Having arrived at an opinion as to the cause of a given ulcer, and placed it in one or other of the above groups, the next question the surgeon has to ask himself is, "In what condition do I find this ulcer at the present moment?"

Any ulcer may be said to be in one of three states: it is either healing, stationary, or spreading. It is true that we frequently find healing going on at one part while the ulcer is spreading at another.

1. *The Healing Ulcer.*—The process of healing in an ulcer is brought about by the formation of granulation tissue, which becomes converted into fibrous tissue, and is covered over by epithelium growing in from the adjacent skin edges.

The characters of an aseptic healing sore have already been described (p. 2), and we have seen that these characters constitute the ideal state of an ulcer. Save as a result of treatment, however, we seldom meet with ulcers in the healing state clinically.

2. Those that are *stationary*—that is, neither healing nor spreading—may be in one of several conditions.

(*a*) *The Weak Condition.*—Any ulcer may get into a weak state from receiving a blood-supply which is defective either in quantity or in quality.

The granulations on the base are small, smooth, and of a pale yellow or grey colour. The discharge is small in amount, and consists of thin serum and a few pus cells. This dries on the edges and forms a scab which prevents the growth of epithelium.

Should the part become œdematous, either from general causes, such as heart, kidney, or liver disease, or from local causes, such as varicose veins, the granulations share in the œdema, and a large quantity of thin serous discharge escapes, but no healing takes place.

The excessive use of moist dressings leads to a third variety of weak ulcer, namely, one in which the granulations become large, soft, pale, and flabby, projecting beyond the level of the skin, and overlapping the edges, which become pale and sodden and cease to grow. This constitutes what is popularly known as "proud flesh." The same condition may arise when induration around prevents contraction of the sore.

(*b*) *The Callous Condition.*—This condition is usually met with in ulcers on the lower third of the leg, and is often associated with the presence of varicose veins. The want of healing is mainly due to the impeded venous return and to the œdematous and indurated condition of the parts around. This induration of the surrounding tissues results from coagulation and partial organisation of the inflammatory effusion, and prevents the contraction of the sore necessary to repair. The base of a callous ulcer lies at some distance below the level of the swollen, thickened, and white edges, and presents a glazed appearance. Such granulations as are present are unhealthy and irregular in size. Foul-smelling yellow pus or sloughs cover the surface, from which a quantity of thin serum exudes. As a rule the condition is painless. The sufferers from this variety of ulcer usually belong to the labouring classes who are underfed, overwrought, wanting in cleanliness, and often excessive in the use of alcohol.

Bone Changes.—The prolonged hyperæmia of the tissues in relation to a callous ulcer of the leg often leads to peculiar changes in the underlying bones (Reclus). The periosteum is abnormally thick and vascular, the superficial layers of the bone become injected and porous, and the bone as a whole is thickened. "The surface is covered with irregular stalactite-like processes of foliaceous masses, which to a certain extent follow the line of attachment of the interosseous membrane and of the intermuscular septa" (Cathcart). When the whole thickness of the soft tissues is destroyed by the ulcerative process the area of bone which comes to form the base of the ulcer projects as a flat, porous node. In course of time the ulcer eats its way into the bone and produces depressions or erosions on its surface. These changes have often been mistaken for primary bone diseases.

3. *Ulcers which are spreading* may be met with in one of several conditions.

(*a*) *The Inflamed Condition.*—Any ulcer may become acutely inflamed as a result of fresh infection with acute bacteria. Mechanical irritation, such as is produced, for example, by direct injury, by the pressure or friction of ill-fitting splints or bandages, or even by excessive use of the part, tends to aggravate the inflammation, as does also chemical irritation by strong or unsuitable antiseptic applications. The most typical example of an inflamed ulcer is the venereal soft sore. The base of the ulcer becomes red and angry looking, the granulations disappear, and a copious discharge of thin yellow pus mixed with blood escapes. Sloughs of granulation tissue or of connective tissue may form. The edges become red, ragged, and everted, and the ulcer increases in size by spreading into the inflamed and œdematous surrounding tissue. Such ulcers are frequently multiple. Pain is a constant symptom and is often severe, and there is usually some constitutional disturbance.

(*b*) *The irritable condition* is met with in ulcers which occur, as a rule, just above the external malleolus in women of neurotic temperament. They are small in size and have prominent granulations, and by the aid of a probe, points of excessive tenderness may be discovered scattered over the surface of the ulcer. These, Hilton believed, correspond to exposed nerve filaments. The small ulcers met with in gouty subjects are also liable to pass into this irritable condition.

(*c*) *The phagedænic condition* is the result of an ulcer being infected with specially virulent bacteria. It often occurs in syphilitic ulcers, and leads to a very rapid and destructive infiltration of the surrounding tissues, with the formation of sloughs and much pus. All the signs of infiltration, both local and constitutional, are present to a marked degree, and the absorption of toxines may lead to a fatal result.

(*d*) *The hæmorrhagic condition* is seen in its most typical form in scorbutic ulcers. The sore is swollen and vascular, bleeds very readily, and is often covered with a thick coagulum. Ulcers which have been brought into a weak condition by too much poulticing frequently bleed freely, as do also those associated with varicose veins should a vein become eroded.

TREATMENT OF ULCERS.—The prompt and patient treatment of ulcers is a matter of great practical importance. An ulcer is not only an immediate cause of suffering to the patient, crippling and incapacitating him for his work, but is a distinct and constant menace to his health. The prolonged discharge reduces his strength; the open sore is a possible source of infection by the organisms of suppuration, erysipelas, or other specific diseases. Phlebitis, with formation of septic emboli, leading to pyæmia, is an ever-present risk; and in old persons it is not uncommon for ulcers of long standing to become the seat of epithelioma. In addition, the offensive odour of the ulcer renders the patient in many cases a source of annoyance and discomfort to his friends; and the expense incurred for dressings is a constant drain on his limited resources.

Principles of Treatment applicable to all Ulcers.—The primary object of treatment in any ulcer is to bring it into the condition of a healing sore. When this has been effected nature will do the rest, provided extraneous sources of irritation be excluded.

Rest is an essential condition to the repair of all ulcers, and is best secured by putting the patient to bed and applying some form of splint. *Elevation* of the part to facilitate the venous return is also most important. The limb should be placed on pillows, or the foot of the bed raised upon blocks, so that the ulcer lies at a higher level than the heart. These measures will at the same time encourage the absorption of inflammatory exudations around the ulcer, and this may be aided by *massage.*

The use of *elastic pressure* or of strapping also accelerates the removal of exudation, and so facilitates the contraction of the sore. When the induration is very dense nothing is so good as *blistering.* A cantharides plaster, or a few coats of blistering fluid, may be applied all over the indurated area, avoiding the open surface.

The *removal of all sources of irritation,* such as unsuitable dressings, ill-fitting splints, irritating applications, and, above all, septic organisms and their products, is imperative.

A septic ulcer must be thoroughly disinfected by washing not only the open surface, but also the skin for some distance around it, with lysol (1 in

100) to remove grease, and then with Lister's strong solution, or carbolic lotion (1 in 20). Hair-covered parts should be shaved. The raw surface should then be swabbed over with undiluted carbolic acid. If the granulations are œdematous and unhealthy they may be removed with a sharp spoon.

An antiseptic dressing of gauze or boracic lint is then applied and changed daily till the wound assumes a healthy appearance.

As in all conditions in which the patient's health is below par, good nourishing food, tonics, and general hygienic treatment are clearly indicated.

By paying attention to these general rules, and by employing certain special measures suited according to the particular varieties of ulcers in hand, the conditions of a healing sore will soon be obtained.

Management of a Healing Sore.—Perhaps the best dressing to apply to a healing sore is a layer of Lister's perforated oiled-silk protective, which is made to cover the raw surface and about a quarter of an inch beyond its margins. Over this three or four thicknesses of boracic lint, or of sterilised gauze wrung out of boracic lotion, or sterilised (boiled) water, are applied, and covered by a moderate quantity of antiseptic absorbent wool. A splint is applied to insure rest, and the part is elevated to avoid congestion.

Once in two or three days is often enough to renew the dressing, and care must be taken to avoid any rough handling of the sore. Any discharge which lies on the surface should be removed by a gentle stream of lotion rather than by rubbing. The area around the sore should be carefully cleansed before the fresh dressing is applied.

In some cases healing goes on more rapidly under a dressing of weak boracic ointment (one-quarter the strength of the pharmacopœial preparation). We have found the daily application of bovinine and similar preparations useful in promoting the growth of epithelium and hastening healing. In other cases any local application seems to irritate the sore and hinder healing. Under these conditions it has been recommended that a wire cage covered with moist antiseptic gauze be placed over the sore and removed frequently to allow of the discharge being bathed from the surface of the sore.

In the treatment of aseptic healing sores, dusting powders and oily or moist dressings should, as a general rule, be avoided.

Treatment of Special Varieties of Ulcers.—Before beginning to treat a given ulcer two questions have to be answered: first, what is the cause underlying this ulcer? and, second, in what condition do I find it? or, in other words, in what particulars does it differ from a healing sore?

If the cause be a local one, it must be removed; if a constitutional one, means must be taken to counteract it. This done, the condition of the ulcer must be so modified as to bring it into the state of a healthy healing sore, after which it will be managed on the lines already laid down.

A. *Treatment in relation to the Cause of the Ulcer.*—I. *Traumatic Group.*—The *prophylaxis* of these ulcers consists in rigidly excluding bacteria, by cleansing crushed or bruised parts with antiseptic lotions, and applying mild, non-irritating dressings, such as boracic lint and corrosive wool, and properly adjusted splints. These measures will often prevent a grossly injured portion of skin from sloughing, and will insure its asepticity should it do so. In the event of the skin giving way the same form of dressing should be continued till the slough has separated and a healthy granulating surface is formed. The protective dressing appropriate to a healing sore is then substituted.

The treatment of *burns and scalds* is described in vol. ii. p. 150.

Pressure sores should be prevented by carefully padding, with rings of absorbent wool, any bony points liable to be unduly pressed upon by splints. The use of a dry dusting powder materially helps the avoidance of pressure sores. When they occur they are treated by protective dressings.

II. In the case of *ulcers due to interference with venous return*, for example those associated with varicose veins, the primary indication is to elevate the limb to facilitate the free flow of blood in the veins, and so insure that a supply of pure, healthy blood shall reach the sore. Should the varicose veins be suitable for operative treatment, this often greatly expedites the healing of an ulcer, although it is to be borne in mind that the operation wound is more liable to become infected in the presence of an ulcer than after this has healed.

The quality of the blood may be improved by the administration of iron, strychnine, quinine, and similar tonics.

III. When an *imperfect nerve-supply* is the main factor underlying ulcer formation, prophylaxis is the chief consideration. In patients suffering from spinal injuries or diseases, cerebral paralysis, or affections of the peripheral nerves, all sources of irritation, such as ill-fitting splints or tight bandages, moist applications, and hot bottles, should be avoided. Any part liable to pressure, from the position of the patient or otherwise, must be carefully protected by pads of wool, air-cushions, or water-bags, and must be kept absolutely dry. The skin should be hardened by daily applications of methylated spirit.

Should an ulcer form in spite of these precautions, the mildest and least irritant antiseptics must be employed for bathing and dressing it, and as far as possible all dressings should be dry. Balsam of Peru is a suitable application in these ulcers until they assume the characters of the aseptic healing sore.

The *perforating ulcer* of the foot calls for special treatment. To avoid pressure on the sole of the foot the patient must be confined to bed. As the main local obstacle to healing is the down-growth of epithelium along the sides of the ulcer, this must be bodily removed by the knife or sharp spoon. The base also should be excised and any bone which may have become involved should be gouged away, so as to leave a healthy and vascular surface. The cavity thus formed is stuffed with iodoform gauze and encouraged to heal from the bottom. After the ulcer is healed the patient should wear in his boot a thick felt sole with a hole cut out opposite the cicatrix. When a joint has been opened into, the difficulty of thoroughly getting rid of all unhealthy and infected granulations is so great that amputation is the speediest and most satisfactory treatment. It is to be borne in mind, however, that ulcers sometimes recur on the stump after amputation.

Stretching of the plantar nerves has been successful in hastening the healing of perforating ulcers (Chipault).

The treatment for any nervous disease or glycosuria which may coexist is, of course, clearly indicated.

The ulcer which forms under callosities on the sole of the foot is treated by paring away all the thickened skin, after softening it with soda fomentations, removing the unhealthy granulations, and applying stimulating dressings.

IV. *Treatment of Ulcers due to Constitutional Dyscrasiæ.*—When ulcers are associated with such constitutional diseases as diabetes, Bright's disease, scurvy, or gout, these must be treated on general principles.

Tuberculous and syphilitic patients must also receive the appropriate medicinal and dietetic treatment for their general conditions.

The *tuberculous ulcer*, however, calls for special local treatment, which, in the first place, consists in the thorough removal of all tissue invaded by the bacillus or its products. By means of knife, scissors, or sharp spoon, all foci of tuberculous disease, whether in the skin or in deeper parts, must be freely removed, so as to leave a healthy surface from which granulations may spring up. Should the raw surface left be extensive and likely to result in an unsightly scar, much benefit may result from skin-grafting.

In some cases the area involved is so extensive that the surgeon may hesitate to excise it bodily. The alternative is to clip or scrape away all grossly diseased tissue and granulations, to slit up all undermined sinuses, and then to purify everything with undiluted carbolic acid, after which an ordinary boracic dressing is applied. By many iodoform is held in high esteem as an agent which counteracts the tubercle bacillus and its products.

The healing of such sores is often slow and tedious, and experience shows that frequent changes in the dressings employed are often beneficial.

The Syphilitic Ulcer.—No ulcerative process responds so readily to medicinal treatment as the syphilitic ulcer does to full doses of potassium iodide and mercury and the local application of black wash. When the ulceration has lasted for a long time, however, and is widespread and deep, the duration of treatment is materially shortened by a thorough scraping with the sharp spoon.

B. *Treatment in relation to the Condition of the Ulcer.*—1. *Ulcers in a Weak Condition.*—If the cause of the weak state of the ulcer be general anæmia, or kidney disease accompanied by œdema, these affections must first be treated on general medical lines. Locally the imperfect granulations should be scraped away, and stimulating agents, such as red lotion or sulphate of copper (two grains to the ounce), applied to the raw surface till healthy granulations form.

Frequently this state of ulcers is due to an indurated condition of the surrounding tissues, or to the base of the ulcer having become adherent to bone or dense cicatricial tissue. In such cases incisions into the parts with a view to facilitating contraction are most useful.

When the ulcer has got into a weak condition from the prolonged use of moist dressings, these must be stopped, the redundant granulations clipped away with scissors, the surface rubbed with a silver nitrate stick or a piece of sulphate of copper (bluestone), and dry dressings applied.

When the ulcer has assumed the characters of an aseptic healing sore a few Thiersch grafts should be applied to hasten cicatrisation.

2. *Ulcers in a callous condition* call for treatment in three directions: (1) The venous return must be facilitated by elevation of the limb, the removal of all constricting appliances, and the employment of massage. (2) The induration of the surrounding parts must be got rid of before contraction of the sore is possible. For this purpose the free application of blisters, as first recommended by Syme, leaves little to be desired. Liquor epispasticus painted over the part, or a large fly-blister (emplastrum cantharides) applied all round the ulcer, speedily disperses the inflammatory products which cause the induration. Pressure applied by imbricated strips of adhesive plaster or by elastic bandages is more troublesome and less satisfactory than Syme's method. (3) The septic element in the ulcer must be eliminated. When the ulcer is very foul, relays of charcoal poultices (three parts of linseed meal to one of charcoal), maintained for thirty-six or forty-eight hours, are useful as a preliminary step. The base of the ulcer

and the thickened edges should then be freely scraped with a sharp spoon, and the resulting raw surface sponged over with undiluted carbolic acid, after which an antiseptic dressing is applied and changed daily till healthy granulations appear. When these are slow to form, the sore may be stimulated by a dressing of boracic lint wrung out of red lotion and covered with a layer of gutta-percha tissue. A more radical and very successful method of treatment consists in excising the whole ulcer and grafting the raw surface left.

So soon as the ulcer assumes the characters of an aseptic healing sore, it should be covered with Thiersch skin-grafts, which form a much better cicatrix than is left when the ulcer is allowed to heal without such aid.

Ambulatory Treatment.—When the circumstances of the patient forbid his lying up in bed the healing of the ulcer will be much delayed. He should be instructed to take every possible opportunity of placing the limb in an elevated position, and must constantly wear a firm bandage of *elastic webbing.* This webbing is porous, and admits of evaporation of the skin and wound secretions, an advantage it has over Martin's rubber bandage. The bandage should extend from the toes to well above the knee, and should always be applied while the patient is in the recumbent position with the leg elevated, preferably before getting out of bed in the morning. Additional support is given to the veins if the bandage is applied after the method suggested by Heron Watson.

Unna's Bandage.—A bandage stiffened with gelatine is useful, but somewhat inconvenient for the class of patients who usually suffer from this condition.

3. An *inflamed condition* of an ulcer is usually the result of a fresh infection by acute bacteria, and of external forms of irritation. Rest, elevation, and the application of moist antiseptic and soothing dressings are the indications for treatment. Ichthyol ointment spread on lint and applied to the surrounding parts is very soothing. Much relief is often given by making a free incision into the ulcer and the surrounding inflamed parts. A preliminary painting with undiluted carbolic acid will help to check the spread of the bacteria.

The *phagedænic* ulcer is simply an aggravated degree of the inflamed variety produced by some virulent organism or poison, and calls for more energetic treatment to arrest its spread, which is often rapid and destructive. The whole of the affected surface may be touched with the actual cautery at a white heat, and the seared surface sponged over with pure carbolic acid. A simple boracic dressing or iodoform gauze is then applied.

4. The *irritable* state of an ulcer may depend upon constitutional neurotic tendencies, uterine irregularities, or upon a gouty diathesis, and in treatment these factors must be counteracted. Locally the most satisfactory treatment is complete excision and subsequent skin-grafting. Failing this, the use of the sharp spoon, silver nitrate, or pure carbolic acid may be tried. Hilton found that small transverse incisions on the proximal side of the tender spots gave relief from the pain, probably by dividing the exposed nerve filaments.

5. A *hæmorrhagic condition* is more or less accidental, and must be treated according to whether the bleeding results from blood causes as in scurvy, or from excessive friability of granulations as in some cases of weak ulcers.

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HÆMORRHAGE.—This may occur immediately after birth from slipping of the cord ligature. A more important kind is spontaneous hæmorrhage occurring usually about the fifth day, when the cord separates; it may occur, however, as early as the second or as late as the fifteenth day. Some of these cases have a hæmophilic ancestry; in a few congenital syphilis is present; by some observers imperfect closure of the umbilical vein has been thought to be the cause (hæmorrhagic fistula). Male children are affected in 75 per cent of the cases. The result is usually fatal. In about half the cases jaundice is present with subcutaneous hæmorrhages or purpuric spots in different parts of the body. In some cases there has been loss of blood from the rectum, bladder, or gums. The treatment is unsatisfactory, the hæmorrhage being usually stopped, but after a time recommencing. Pressure and various styptics have been tried: cauterisation is inadvisable. Underpinning, or some method of ligature, seems to have been most successful. Possibly the administration of calcium chloride and the local use of suprarenal liquid might be useful.

SEPSIS AND INFECTIVE PROCESSES.—It cannot be too strongly insisted that the ligature and subsequent treatment of the cord stump should be conducted on ordinary antiseptic principles. Inflammation at the umbilicus (omphalitis) in the new-born may be slight, or may go on to ulceration, cellulitis, gangrene, general septicæmia, or pyæmia, this last condition depending probably upon the passage of septic thrombi by the umbilical vein to the liver, lungs, or elsewhere. Erysipelas or general peritonitis may occur, and are almost universally fatal. Severe icterus neonatorum is due to umbilical septicæmia. Diphtheria has affected the umbilicus alone with a fatal result. In tetanus neonatorum the umbilicus is probably the point of infection, and the bacilli can be detected in the pus at the navel.

In adults, especially fat people, the accumulation of dirt and sebaceous matter in and around the umbilicus may give rise to inflammation or ulceration; erysipelas, cellulitis, or abscess may follow. Actual concretions, made up principally of inspissated sebaceous material, have also been found.

Treatment must be conducted on ordinary lines. In omphalitis mercurial ointment and lotion are of value. The umbilicus may be removed if necessary.

ECZEMA.—This occurs both in children and stout adults, being in some cases associated with want of cleanliness, in others with the presence of tumours.

SYPHILIS.—Ulcerative processes, jaundice, and hæmorrhage are more common in congenital syphilis. Hunterian chancres and condylomata have been seen at the umbilicus.

FISTULÆ.—(*a*) *Fœcal.*—These, when appearing at the fall of the cord, are due either to the persistence of the omphalo-mesenteric duct (Meckel's diverticulum), in such cases the bowel below the diverticulum being normal or more or less closed, or to inclusion of a piece of bowel in the cord ligature. The fistulous opening may be quite minute, being perhaps situated at the apex of a little tumour consisting of prolapsed mucous membrane, or if the opening is wide, large portions of intestine may be everted through it. Rarely the small gut has been found to open at the umbilicus just above the normal position of the cæcum, all the intestines below this point being absent.

The treatment of these fistulæ depends upon the condition of the bowel below: a minute opening may close without treatment, in other cases a plastic operation may be necessary: finally, a wide diverticulum may be detached from the umbilicus and removed. If the bowel below is closed the umbilical opening must be kept patent.

Fistulæ of later date, in children, are usually due to tuberculous peritonitis. In adults they may arise from peritonitis, tuberculous or from other causes, especially appendix trouble, or from rupture of a strangulated hernia, cellulitis of the abdominal wall that has involved the bowel, or from injury. In rare cases worms have passed through the umbilicus after the adherence of a circumscribed ulcer of the gut. Umbilico-gastric fistulæ, from simple or carcinomatous ulcer of the stomach, may occur.

The treatment of these cases is difficult, often can be merely palliative, and must be conducted on ordinary lines.

(*b*) *Urinary.*—These are always due to a patent urachus; see under "URACHUS," p. 41.

(*c*) *Biliary.*—These are very rare. They may be congenital, in connection with some abnormality of the gall-bladder or ducts; or more commonly acquired, when, if due to injury or certain inflammatory processes, they may close spontaneously or after operation; but if due to a malignant growth or stricture of the common bile-duct they are best left alone. Gall-stones may pass through these abnormal openings.

(*d*) *Purulent.*—These are due to the opening of an abscess associated with peritonitis from tubercle, appendicitis, or some other cause, intestinal contents and pus being both present in the discharge; from suppuration in an ovarian or hydatid cyst, bile being also present in the latter case; from a urachal abscess, when urine is mixed with the pus; from an abscess in the abdominal wall, or from similar causes.

PERSISTENT OMPHALO-MESENTERIC DUCT.—Hence arise fæcal fistula (see above), adenoma in the new-born (see below), cysts containing a modified succus entericus, or sacs discharging a similar fluid by a fistulous opening at the umbilicus. Such conditions may be readily understood by remembering that the duct may undergo complete involution in one part, another may remain as a solid fibrous cord, another may undergo development into a structure identical with that of the small intestine.

TUMOURS.—Of innocent tumours the most important are the polypi; of these the so-called *granulomata* are due to overgrowth of granulation tissue after the fall of the cord. They are little, pedunculated growths, strawberry-coloured, varying in size from a pea to a hazel nut, bleeding easily, and secreting an abundance of sero-purulent fluid. Possibly some originate from allantoic remnants. Microscopically the little tumours show round and fusiform cells and many fine vessels. They may drop off spontaneously or on the application of powdered nitrate of lead. If not, a ligature round their base soon causes desiccation and separation.

The other class of polypi, appearing at the same period, are the *adenomata.* Here a portion of the omphalo-mesenteric duct persists, and the mucous membrane, prolapsing and proliferating, gives rise to a little tumour having the structure of small intestine. Such tumours, the writer has found, have a solid cord passing back from their base to the apex of a Meckel's diverticulum. Clinically we find a red vascular tumour much resembling a granuloma, but having in the middle a little canal ending blindly. Their appearance much resembles rectal prolapse in an infant or a rectal polypus. They grow slowly and may remain stationary for months, seldom becoming larger than a cherry. There is an abundant secretion of fluid which soaks the child's clothes. The writer measured this in one case, and found it averaged 10 to 15 c.c. daily. The fluid was viscid, clear, and distinctly alkaline. It contained albumin, it had no digestive action on proteids or starch. Microscopically these tumours are covered with a layer of glands identical with Lieberkuhn's follicles, some of which are proliferating. Beneath these are connective tissue and unstriped muscular fibres. The tumours in every way resemble those which surmount a minute fæcal fistula, and are evidently identical with them except that the part connecting them with the Meckel's diverticulum is impervious. They can be removed by ligature or by the knife.

Three cases of umbilical polypus of similar naked-eye appearance showed microscopically the structure of the pyloric end of the stomach: in one (Tillmanns) the secretion was abundant, acid, contained pepsin, and digested the skin.

Other innocent tumours are rare. Angeiomata occur, and sometimes surmount a congenital hernia; dermoid and sebaceous cysts have been seen and sometimes suppurate. Empty hernial sacs which have been tied off may form serous cysts at the navel. Lymphangeiomata have been described, sometimes in association with ovarian cysts. Papillomata, fibromata, and myxomata also occur, but with the above must be regarded as pathological curiosities. Subperitoneal lipomata are common near the umbilicus, making their way to the subcutaneous tissue along the track of one of the perforating arteries.

Malignant tumours are more frequent than benign: scars are not infrequently the seat of malignant change, especially when subjected to the irritation resulting from accumulation of dirt and sebaceous material. Of primary growths epithelioma is the commonest, not differing in appearance from similar growths elsewhere, but glandular enlargement is uncommon, while the tumour has a tendency to grow deeply, invading the peritoneum and intra-abdominal organs. In some cases the abdominal wall around is hardened by the growth, forming a kind of cancer *en cuirasse.*

Secondary carcinomatous growths at the umbilicus are not uncommon, and sometimes invade a hernial sac, the growth spreading from the contained omentum to the sac wall. The primary growth may be in the stomach, intestine, colon, ovary, uterus, peritoneum, or liver. A liver growth may travel to the umbilicus along the lymphatics of the round ligament. Sometimes the intra-abdominal growth is latent.

Sarcomata occur at the umbilicus, but are very rare. Rodent ulcer has been described.

With regard to treatment, primary growths are removed by an elliptical incision, and the same mode of treatment is applicable to secondary growths, if advanced and troublesome, the operation giving an opportunity for exploration of the abdominal cavity.

HERNIA AND EXOMPHALOS.—See the article "HERNIA" in vol. iv.

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Unconsciousness.

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The primary and obvious problem of psychology is the explanation of psychical phenomena. By "explanation" is meant the reduction of the phenomena of our inner world, which are given merely in time, to those actual events which lie at their foundations, and the establishment of the laws according to which the former follow from the latter. For Volkmann the fundamental principles of psychology lie in the actual psychic events, and his genetic method of psychology traces and explains the development of mental life by a combination of empirical and speculative or metaphysical principles.

For the present purpose it would be a work of supererogation to review the polemical and critical discussions on the science of the phenomena of consciousness, for this would involve the production of a treatise on psychology both descriptive and explanatory. It will be expedient to adopt merely some sort of attitude towards those implications of the known phenomena of consciousness, without reference to the various metaphysical hypotheses which have been introduced solely in the attempt to explain the facts.

In our study of the concept of mind it is important to recognise the definite standpoint that all consciousness, and every phenomenon of consciousness, ought to be considered as a form of functioning, and not as a mere differentiation of content. And, just as the task of scientific psychology is truly a description and explanation of phenomena of consciousness, considered as forms of active functioning, so our present task of considering the morbid phenomena or disruptions, so to speak, of consciousness must perforce be descriptive and explanatory without falling back upon the speculative or metaphysical doctrines as to the ground and essence of all mental life.

Active discriminating consciousness and consciousness of *passive* contents must be differentiated and recognised as being in their totality the sum of all the so-called elements comprising consciousness, even though they are only two sides of one and the same consciousness. Inasmuch as consciousness involves the sum total of mental life with its successions and laws of sequence, so "unconsciousness" ought to involve a full consideration of the disruptions of successions of psychoses which derive their characteristics from the nature of their sequence, and of the laws which are shown by the states of consciousness in this sequence.

For simplicity the various cognitive states of consciousness will herein be termed "knowledge," arrived at through the process of development and involving all forms of intellectual activity. Unconsciousness, therefore, implies interference with knowledge, and this interference may be partial or complete.

The Physical Basis of Consciousness is a subject which has engaged the attention of nearly all writers in physiology, psychology, and philosophy. Here we grant that the mind holds intercourse with the external world through the medium of the nervous mechanism, and any disorder or disease of that mechanism may impair or suspend the intercourse. It is only when we have gained an adequate knowledge of the physiological data, and are able to place them in juxtaposition to concomitant psychological data, that we shall be able to cope with this most difficult of all questions of mental physiology.

Hitherto the tendency has been to assign causes where causes cannot be shown to exist, and deduce extempore doctrines from a very partial view of the influence of cerebral disease upon the phenomena of the mind, and these partial deductions have served to form the basis of an irrational materialism. It will be readily understood that some hallucinations and mental changes cannot be explained by physiological perversion; similarly in discussing the phenomena of unconsciousness we must simply assume that disease of the cerebrum impairs or suspends the intercourse of the substantially unknowable mind with the data derived from the external world.

The scheme of the hierarchy of nervous centres enunciated by Hughlings Jackson is based on an anatomico-physiological basis, and a reference to this scheme serves to explain upon a rational hypothesis many of the phenomena of unconsciousness.

Briefly stated it is as follows:—

"1. The lowest motor centres are the anterior horns of the spinal cord, and also the homologous nuclei for motor cranial nerves higher up. They extend from the lowest spinal anterior horns up to the nuclei for the ocular muscles. They are at once lowest cerebral and lowest cerebellar centres; hence lesion of them cuts off the parts they represent from the whole central nervous system.

"The lowest centres are the most simple and most organised centres; each represents some limited region of the body indirectly, but yet most nearly directly they are representative. The middle motor centres are the convolutions making up Ferrier's motor region and the ganglia of the striatum. These are more complex and less organised, and represent wider regions of the body doubly indirectly; they are representative. The highest motor centres are convolutions in front of the so-called motor region. I say so-called, as I believe, and have urged for many years, that the whole anterior part of the brain is motor, or chiefly motor.[1] The highest motor centres are the most complex and least organised centres; and represent widest regions (movements of all parts of the body), triply indirectly; they are re-re-representative. That the middle motor centres represent over again what all the lowest motor centres have represented, will be disputed by few. I go further, and say that the highest motor centres (frontal lobes) represent over again, in more complex combinations, what the middle motor centres represent. In recapitulation there is increasing complexity, or greater intricacy of representation, so that ultimately the highest motor centres represent, or, in other words, co-ordinate, movements of all parts of the body in the most special and complex combinations."

In regard to the scheme of the sensory centres his conclusions are:—(1) That the highest (chiefly) motor centres, parts in front of the so-called motor region, make up the physical basis of consciousness; and (2) that just as consciousness represents, or is, the whole person psychical, so its anatomical basis (highest centres) represents the whole person psychical, represents impressions and movements of all parts of his body; in old-fashioned language, the highest centres are potentially the whole organism. States of consciousness attend survivals of the fittest states of centres representing the whole organism.

Meynert endeavoured to prove a logical sequence in the evolution of association, and Waller[2] tried to demonstrate the essential similarity of neural processes concomitant with the whole range of subjective phenomena, from the simplest sensation to the most complex judgment. Hitherto the logical mode of symbolising neural processes has merely resolved itself into a disquisition upon the ordinary rules of the syllogism with, in addition, the conception that the physical organism in some way or other subserves the phenomena of sensation.

It must suffice here to state that the various presentations and representations in consciousness are correlative states to physiological activities. Every presentation and representation is an objective content of consciousness. The sum total of the complex physiological activities become manifested as objective contents of consciousness; the *ego* does not view the activities themselves, it merely becomes cognisant of their mental correlatives as objective states. The writer has elsewhere said :[1]—"The study of the nervous mechanism has disclosed to us that just as our bodies are associated with the activities of the cosmical system, so our organic nervous structures are associated with the objective phenomena of consciousness. Further, the details of physiology and anatomy would appear to point to the fact that some ultimate and intra-bodily activity is essential to, and possibly conditions every diversification of the sensory and other kinds of experience. Beyond this we cannot go. The mere experience of sensory consciousness in itself affords no scope for ratiocination. In other words, our cerebro-spinal system is capable of receiving and of propagating specific agitations, and also of exerting, in some way or other, a determinate modification of activity in its substance, but we do not in the least degree understand the *modus operandi* whereby we experience the current vicissitudes of consciousness.

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[1] *Brit. Med. Journ.* March 6, 1869.

[2] Waller, *Brain*, 1892, p. 355.

The question as to whether individual parts of mental operations are associated with definite parts of the cortex has, in the case of aphasia and allied conditions, assumed fairly definite proportions; but at the best we must remember, that the clinical manifestations in these cases may furnish us simply and solely with evidences that the physical paths of conduction, or the organic substrata, are not performing their physical functions satisfactorily. When we attempt to deal with complex mental activities, we cannot imagine any specific functions in the nervous elements which would serve as physical counterparts, and the presence of a chaotic mass of tracts, cells, and other nervous elements, viewed either singly or in combination, do not suggest any explanation of the very simplest psychical process.

The processes of consciousness are manifestly dependent upon the physical organisation of the nervous system, and the cerebral cortex appears to have a more direct and intimate relation with "knowledge" than is manifested by other regions of the cerebro-spinal system.

Professor James has asked the question : "Is consciousness which accompanies the activity of the cortex the only consciousness that man has? or are his lower centres conscious as well?" He conceives that the lower centres themselves may possibly have a "split-off" consciousness of their own similarly ejective to the cortex consciousness. This question may be answered by saying that the cortex cerebri is the sole organ of consciousness in man, and if there be any consciousness pertaining to the lower centres it is a consciousness of which the self knows nothing. But the possibility of consciousness pertaining to any of the lower centres is not to be estimated by the complexity or fitness of the reactive manifestations as viewed objectively, otherwise we are free to assume the existence of consciousness in still lower centres of the cerebro-spinal system ; for, as is known to be the case, such lower centres are capable of effective reaction apart from the cerebral influence. The facts, as presented to us by a study of the evolution of the central nervous system, would lead us to the conception that our physical organism is eminently adapted to react to stimuli derived from environment ; and of our physical organism the central nervous system is the more immediate means of effecting such reaction ; it is through this nervous system that the outside world is perceived subsequently by the mind. Beyond this we cannot go. A satisfactory reply, as to whether the activities of the lower or subcortical structures are accompanied by subjective expressions in consciousness, can only be given when we have eliminated the cortex in its entirety from its substructures.

At this point we may ask, Does consciousness exist only when the cortex cerebri is functionally active as a whole? or may consciousness exist in conjunction with activities occurring in one or several regions, while other regions are inactive as concomitants of mental phenomena? the answer is readily conceivable, and it is fair to assume that full knowledge is dependent upon complete seriality of presentation and representation derived from activities within the *whole* of the cortex, and possibly incomplete knowledge or partial consciousness may be derived from a disruption of that seriality or sequence through inactivity of *part* of the cortex. The phenomena of double consciousness and the various epileptiform states would appear to warrant this assumption, and by its aid some of the greatest difficulties of our subject may be unravelled.

Before discussing this question more fully, however, it is advisable that we should again refer to Hughlings Jackson's scheme of evolution. We have in this scheme (1) a level for representations, (2) a level for re-representations, and (3) another for re-re-representations. The difficulty of determining what areas of the cortex are concerned with the manifestations of subjectivity, while unsurmountable on the assumption that any areas are concerned more directly than others, disappears with the hypothesis that all areas are concerned directly and indirectly, and that subjectivity is merely in its *completeness* dependent upon a complete psychical seriality and sequence, and that this completeness of seriality is dependent upon a complete functioning of the whole cortex.

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[1] Hyslop, *Mental Physiology*, p. 133.

Were the præfrontal lobes the physical substrata for the reception of re-re-representations, these lobes would be essential for the proper correlation of modes of matter to modes of mind. We have no proof, however, that any part of the human cortex is indispensable to the manifestations of subjectivity. The contents of consciousness—previously acquired, and serving as the mental data upon which the ego preserves its continuity—may be rendered temporarily inert by interference with the modes of matter concerned with the local memories (*e.g.* word-deafness, etc.), but this is all. No amount of philosophy or argument will explain the evolution of a subject from an object. Neither will it prove the nature of that subject by the demonstration of the sources from which it receives its objective supplies, or data in consciousness.

We have, therefore, ample experimental and pathological evidences that the mind can see, feel, and will, in spite of the physical and structural discontinuities of the brain cortex. Destruction of any brain-areas is, so far as our knowledge goes at present, not necessarily attended by alteration in the subjectivity of the mind. We may destroy, extirpate, or sever the connection of any of the cortical areas, and we can thereby cut off present supplies, or even render the results of former activities inert (memory); beyond this, however, we cannot go.

There is no way of evading the difficulty of adapting the subjectivity of the mind to anatomico-physiological data. When we advance in our knowledge of the data of consciousness (which are much the same now as they were) and the relations of the various structures of the brain, we may be able to formulate some more definite doctrines as to cerebral localisation. In the meantime, however, we can offer no ultimate solution of the one great difficulty. If we localise determinate activities within restricted areas, we become responsible for an account of some supreme site, where the mental correlates of these activities are viewed by the subject. Or if, on the other hand, we are indifferentists, we find ourselves confronted with the problem of having to account for the mode by which the subject obtains its view of the objects correlated with physiological activities in widely apart localities. It is needless to say, that whichever view we take, our difficulty will be reaching the truth so far as the subjectivity is concerned.

The answer of cerebral anatomy and physiology to the question of localisation of consciousness has, therefore, been of little value hitherto, and we are as yet unable to account for the phenomena of mind by the study of material structures. The mere fact that the formerly experienced contents of consciousness are rendered inert or incapable of being revived (as in cases of word-blindness and word-deafness, etc.) proves nothing, inasmuch as we are unable to prove whether the contents themselves are destroyed or only rendered inert through lesions of the tracts through which their causal or effectual activities have been or should be transmitted.

The weighty and philosophical arguments of Hughlings Jackson, that, from an evolutionary standpoint, each and every part of the body must be represented in any one unit of the cerebral cortex, would appear to bear out the contention that consciousness or knowledge is not dependent upon one special area, but upon the integrity and active co-operation of all.

Amœboidism of Nerve Cells.—Without entering upon a discussion as to the value of all the ingenious and suggestive views concerning the amœboid movements of nerve-cells, it will simplify the subject if these views are here briefly referred to.

The *neuron theory* holds that every nerve-cell with its protoplasmic proceeds, axis-cylinder process, and collaterals, is an anatomical unit, structurally independent of other nerve-cells. The researches of Cajal, Kolliker, Duval, etc., lead one to adopt the view of the contiguity of the ramifications of the neurons, as against the view of the continuity entertained by Gerlach, but it is natural to inquire whether these protoplasmic ramifications are susceptible of approaching to, or receding from one another, by virtue of their contractile properties. In 1890 Rückhardt suggested that these movements might account for the differences in the functional states of nervous areas, and in 1894 Lepine suggested that possibly sleep (*vide* article "SLEEP," *Ency. Med.*) might be due to the retraction of cellular prolongations leading to their isolation from one another.

In 1895 Duval argued that as imaginations, memory, and association of ideas become more active under the influence of certain agents (tea, coffee), whose functions would be to excite amœboid movements in the contiguous extremities of nerve-cells, it is therefore conceivable that the ramifications do approach each other and thereby facilitate the passage of impulses. The numerous experimental researches on fatigued animals appear to show that fatigue of the nervous elements brings about the isolation by retraction of the cellular prolongations.

The earliest anatomical researches upon the amœboid movements of cells were carried on upon retinal and olfactory cells, and by analogy the theory of nervous amœboidism holds good. The theory of *nervi-nervorum*, advanced to explain how the arborisations can be incited to approach or separate from one another, finds favour with many writers. The theory assumes that centrifugal nerve-fibres preside over the protoplasmic movements of the ramifications of the nerve-cells in an analogous way to vaso-dilatation and vaso-constriction. For the evidences afforded as to the existence of these centrifugal nerve-fibres the reader must refer to the numerous works upon the subject, and he will find an able summary of the subject in Ford Robertson's text-book of *Pathology*, in which the matter is summarised in the statement that the present position of the controversy justifies the conclusion that no discovery that has yet been made really weakens the case for the neuron theory.

UNCONSCIOUSNESS may be *partial* or *complete*. By "partial" is meant a suspension of psychical or physical elements which are necessary to a full or complete consciousness. By "complete" is meant the seriality of thought and discrimination (or "*knowledge*") which is psychically available by reason of a concomitant structural contiguity of function within the cerebral cortex, whereby the translation of physical events, both external and internal, is fully operative. By fully understanding the meaning of these terms the subsequent attempts to deal with the complicated subject of double consciousness will be more comprehensive.

Partial loss of consciousness is exemplified in those individuals who by reason of disorder or disease suffer from partial amnesia. It is commonly assumed that every recollection has its seat in a definite and determinate portion of the cerebral hemispheres. Each portion has its special function to perform, but is in intimate relation with its fellows. Ribot compares each particular form of memory with a contingent of clerks charged with a special and exclusive service, any one of these departments might be abolished without serious detriment to the rest of the work, and that is what happens in these partial disorders of memory. It may be objected that in these partial amnesias there is not immediate loss of consciousness to present facts, but the answer to such an objection is manifest. Any present data which are incapable of being incorporated with the general stream of consciousness, seriality of thought, or knowledge, by reason of discontiguity or discontinuity of function of the neurons, are outside the limit of "knowledge," and the reflex, if there be one, is the result of activities within the undamaged cerebral remainder, and therefore only incomplete, and oftentimes merely automatic. The writer has elsewhere divided the forms of partial amnesia into two groups, viz. (*Mental Physiology*, p. 361):—

(1) Those forms in which there is a loss of memory of a series of mental states, without any obvious interference with the activities of the mind as a whole; (2) those forms in which the loss is due to disease or injury of certain nerve-elements. Among the insane one meets with nearly every form of partial amnesia, and in general paralysis more especially do we find partial loss of consciousness of a class of events derived through the medium of the special senses. In idiots or imbeciles congenital defects of consciousness are

common. The failure to register or interpret impressions through one or several of the special senses results in a permanent defect of consciousness and consequent failure in intellectual development. Before discussing the various states of complete loss of consciousness or coma reference must be made to the various grades of so-called mental automatism, or double consciousness.

Double Consciousness.—This condition has been compared to dream, somnambulistic, epileptic, amnesic, and insane states, and the writer has elsewhere cited instances of the various gradations between them and health ("Double Consciousness," *Brit. Med. Journ.* Sept. 23, 1898). In childhood night terrors or somnambulism may precede a condition in which during the daytime there are moral or volitional perversions, of which in the fully awake state there remains no memory or power to recall. These children usually belong to the group of unstable neurotics who may become criminal or insane according to surroundings. The writer finds much to be said in favour of the hypothesis that dual consciousness is only complete somnambulism. The successive awakening of the senses constitutes a gradation from ordinary sleep to complete somnambulism, which give to the individual the appearance of leading a dual life. Questions of criminal responsibility arise in those cases in which criminal acts are committed in the hypnagogic or in the somnambulistic state. We may assume that the sleep, though apparently profound, has really only suspended some of the highest level functions, leaving uncontrolled play to the lower levels. During the fully awake state the highest level has little or no knowledge of what happened when only the lower levels were at work.

Sometimes, in cases of exhaustion, deep sleep is followed by a partial awakening attended by confusion and pranks of the senses, and later in the day complete awakening. In other types abnormal or automatic states are preceded by profound sleep, the normal state only being reached again after prolonged sleep. After any injury or shock the power of recall of mnemonic images may be inhibited, and recent or remote events may, for the time being, be quite obliterated.

This inhibitory process may extend both backward and forward, and there may, or there may not, be recovery from the loss. It is assumed that either the registration of anterior states is interfered with or effaced; or if persisting, their power of revivification by association with the present is destroyed. In organic brain disease the former is probably the case, whereas in most of the known cases of double consciousness the latter is the probable explanation, and the coupling apparatus between the past and present is rendered inert by some defect in its organisation.

Numerous cases are recorded in which—through injury or shock—a blow on the head, a fall, a fever, or an acute illness may produce effacement from the memory of events of either recent or remote occurrence. Owing to traumatism extensive periods of time may be obliterated. External violence, causing concussion or injury to the brain structures with loss of consciousness, will require great care in the formation of a diagnosis. The fact of the external injury is usually obvious, and the immediate unconciousness may be due to shock or actual damage to the skull, membranes, or brain substance. The writer has seen several cases in which not only has unconsciousness immediately followed the injury, but at a subsequent period, months or even years later, curious anomalies of unconsciousness have occurred. These abnormal states may be likened to double consciousness, inasmuch as the patient may for weeks or even months respond to external impressions in a dazed, confused manner, and be apparently in a degree conscious. On awakening, however, to full consciousness there is more or less complete failure to recall the details of the partially conscious period. The failure to recall events may be complete for several days, but it is not common in such cases to have complete failure in regaining their knowledge.

When dealing with loss of consciousness due to injury, it is important to note that trivial accidents may cause lacerations of the brain substance or even extensive meningeal hæmorrhages. On the other hand, the injury may have occurred in consequence of some form of cerebral seizure. In an epileptic attack the period of unconsciousness is usually of short duration; and the presence of signs of paralysis, unilateral rigidities or clonic spasms, inequalities of the pupils, or conjugate deviation of the head and eyes, will help to indicate the existence of some organic mischief. The three forms of epilepsy—viz., *grand mal, petit mal*, and *epileptic vertigo*—are regarded as but different degrees of the same morbid state, and the types are so common and so well known that it is not necessary to do more than merely refer to them. The coma following epilepsy has in itself nothing distinctive.

Note, however, may be made that many of the hallucinatory auræ preceding the actual attack, also the automatic states either preceding or following the fit, are evidences of partial unconsciousness as compared with the more profound coma.

The next type of unconsciousness is seen in the insane, and as the writer has pointed out ("Double Consciousness," *Brit. Med. Journal*, September 23, 1899), there are two main groups according as the condition is complete or incomplete. In complete alternation the personality of the individual is entirely different in the two states, there is no continuity of thought, and the memory of one state is absent during the occurrence of the other. In the "partial" types the variations may depend upon sensory experiences which are different to those habitual to the normal self, and there may be new bodily sensations, or loss of old ones, and there may be illusions of identity of part or of the whole of the individual.

The *anæsthetic hysterical types* are those in which the symptoms are mainly hysterical with anæsthesia and temporary amnesia. In these cases there are certain "inhibitions" (Janet) or "negative lesions" (Hughlings Jackson) which prevent the recall or revival of the former sensations. Thus, the occurrence of anæsthesia or akinæsthesia may be attended and followed by an amnesia which forms the basis of a change in personality. Another type in which the individual assumes the possession of a mediumship and acts as if animated by others, living or dead, is fairly common. Automatic writing, inspirational speaking, trance utterances, &c., fall into this category.

Psychologically considered it appears justifiable to conclude with regard to all these conditions of partial consciousness that in the abnormal states the permanent group or mass of individual feelings is only in part or slightly subject to the power of volition. There are wanting those conscious accompaniments which go to raise consciousness into self-consciousness, and the disjoining of these bodily feelings and images which go to make up the *ego* removes the background of the awareness of self. The condition, therefore, is one of "sciousness" (James) pure and simple, inasmuch as it does not include those elements or adjustments which go to make up the complete self and which constitute *con*-sciousness.

Physiologically considered it appears fair to assume that consciousness has a diffuse substratum, and the physical equivalents of the elements of consciousness are everywhere throughout the brain substratum. Each unit of the highest evolved parts of the sensorium has its own physical equivalent to consciousness, which exhibits itself under certain physical conditions occurring within that unit. The succession of physical elements constituting seriality of thought, conception, knowledge, is correlative to continuity of action between the units of the cortical substance, and the destruction or inertness of any of the physical correlatives of this seriality appears to be the explanation of these freaks of dual and even multiple personalities.

It now remains to consider those conditions of unconsciousness in some instances termed "coma," and in which the loss of *consciousness is complete.*

The following tabular statement will serve as a guide:—

Unconsciousness due to
- Convulsions
- Epilepsy
- Traumatism (due to injury, sunstroke, etc.)
- Organic brain disease
  - Meningitis
  - Hæmorrhage
  - Embolism
  - Thrombosis
  - Tumours, abscesses, etc.
  - General paralysis
  - Other paralyses
- Toxins . . .
  - Drugs
  - Autotoxines
- Artificial. . .
  - Hypnotism
  - Anæsthesia (chloroform, etc.)

Convulsions occurring in infancy may be caused by fear, anger, improper diet, hyperpyrexia, dentition, entozoa, rickets, cerebral or bodily irritation. Sometimes the seizures are difficult to distinguish from epilepsy, and not infrequently epilepsy may supervene. The convulsions may pass off without doing injury to the cerebral structures, or cerebral congestion or asphyxia may be brought about with serious sequelæ. The attack usually begins with tonic contraction and palmar flexion of the thumbs, succeeded by tonic spasms of particular muscles or group of muscles of the face, arms, legs, or of one side of the body, and sometimes leaving motor impairment or even paralysis.

Consciousness is usually lost, respiration irregular, and face livid. The tonic spasms may simulate the clonic contractions of epilepsy. Treatment resolves itself into removal of the cause of reflex irritation, suitable diet, and removal from unhygienic surroundings.

In adults the convulsions may be *tonic,* affecting any muscles or set of muscles, *static* or convulsive auræ, *rotatory* with general action of the extensor muscles, *unilateral* affecting one side of the body, *epileptiform* simulating epilepsy, *apoplectiform* simulating apoplexy, and lastly *epileptic* or *apoplectic.*

Where certain muscles or sets of muscles are alone affected, consciousness may be retained or be slightly affected. In the other types, however, it is usually completely suspended.

Epileptic coma usually accompanies sensori-motor discharging lesions of the nervous system (*vide* epilepsy) and the symptoms will vary according to the site affected—cerebrum, cerebellum, or spinal cord—and according as the lesion is discharging or destructive in nature. There is no sudden line of demarcation between the minor forms of epilepsy, in which the mental or motor functions are but partially affected, and the graver forms attended by total loss of consciousness and general clonic convulsions.

Briefly enumerated, the various relations of epilepsy to loss of consciousness are:—*Abortive,* with loss of consciousness; *feigned,* in which there is no biting of the tongue, no relaxation of the sphincters, no pupillar anomalies, and none of the post-epileptic phenomena; *gastric, intestinal, laryngeal, renal, ovarian,* and *auditory,* due to reflex irritation; *hysterical* (*vide* hystero-epilepsy); *partial,* limited to one muscle or set of muscles; *cerebral, spinal,* according to the region mainly affected; *Jacksonian,* in which the spasm is in a definite direction; *idiopathic,* without observable lesion; *vaso-motor,* with loss of consciousness, but without muscular spasm; *thalamic,* supposed to be due to a lesion of the optic thalamus with a special sense auræ, and loss of consciousness without muscular spasm; *psychic* or *masked,* with partial or complete loss of consciousness without muscular spasm; *traumatic, syphilitic, malarial, toxic,* etc., due to these factors respectively.

For simplicity these types may be tabulated as follows:—

1. Without loss of consciousness, but with spasm	Abortive	
	Feigned	
	Hysterical	
	Partial	
2. With loss of consciousness, but no spasm	Psychic, affecting one or several senses	
	Masked, or mental automatism	
	Vaso-motor	
	Thalamic	
3. Loss of consciousness and motor spasm	Idiopathic, without known lesion	
	Jacksonian, with local lesion	
	Traumatic, organic lesion usually	
	Reflex . .	Gastro-intestinal Renal Ovarian Laryngeal and auditory
	Hystero-epilepsy	
	Organic disease	Cerebral Cerebellar Spinal
	Toxic . . .	Syphilis Malaria Fevers, etc. Drugs

Concussion and compression of the brain require but brief notice here, as the subject is so fully dealt with in works on Surgery. Concussion includes all those instances in which there is unconsciousness after injury (to a greater or less extent), unaccompanied by paralysis; compression includes all those in which there is paralysis. In concussion the unconsciousness is attended by pale face and cold skin; the pulse is weak, often irregular or imperceptible; the pupils vary, but usually respond to light; breathing is shallow; urine and fæces pass involuntarily, but there is no paralysis of the sphincters nor any other symptoms of paralysis; the temperature is usually lowered. After the stage of collapse the patient can usually be roused. There is, however, usually some headache and drowsiness which may last some time.

Compression is attended by definite evidence of paralysis—stertorous, oppressed, and slow breathing; dilation of pupils, with occasionally insensibility to light; slow pulse, relaxation of the sphincters, coma, and paralysis.

Other cases, however, occur in which the unconsciousness is by no means complete, and there may be delirium with or without spasms or convulsions.

Where the insensibility and paralysis increase in severity and extend to the functions of deglutition and respiration a fatal result is apt to occur.

Sunstroke, when due either to the direct rays of the sun (*coup de soleil*), or indirectly to heat or other influences (*coup de chaleur*), is attended by loss of consciousness. Usually the fatal character of the heat is derived from aerial moisture. The bodily causes arising in connection with faulty habits or diseases of the individual are of special importance, and among these may be mentioned fatigue, over-exertion, overcrowding, bad ventilation, unsuitable dress, retained excretions, defective secretions, in fact, anything tending to debilitate or contaminate the system. Injuries to the head, malaria, scorbutic taint, venereal disease, former attacks of insolation, and alcoholism, all predispose to its occurrence.

Malaria, syphilis, and alcoholism not only play an important part in the etiology of insolation, but they also tend to modify and influence the subsequent history of the individual, and give rise to symptoms of great variety and complexity. The writer found that out of fifty-five cases of affections of consciousness following sunstrokes eight had malaria, five syphilis, and seven had been alcoholic ("Sunstroke" *Dict. Psych. Med.*). In addition to the actual loss of consciousness consequent upon the sunstroke there are apt to be symptoms of varying degrees of severity, due to impaired functional energy of the cerebro-spinal system, and this impairment shows itself either in motor paralysis, sensory paralysis, either of common or special sensation, hyper- and dysæsthesiæ of the nerves of common and special sense, in debility and undue excitability of emotional centres, and in similar states of the cerebral hemispheres and spinal cord. The mental sequelæ are of extreme interest, and the unconsciousness is often attended with meningitis or cerebral damage which may destroy the life or intellect sooner or later, or permanently compromise the whole health or that of some important function.

In many cases the sequelæ may be attributed to the injury the brain suffers during the primary attack, probably from loss of nutrition in syncopal, and from congestion in the apoplectic forms. Of the syncopal, asphyxial, and hyperpyrexial forms of insolation, the two latter appear to be the most important and dangerous, and are more liable to be attended with sequelæ of a degenerative type. In children idiocy and imbecility may result from sunstroke. It must be remembered, however, that parents are ever ready to attribute the idiocy of their children to an accidental fall or blow, so that in any case of idiocy or imbecility attributed to the effects of sunstroke, the existence of an hereditary neurosis, the occurrence of fits, or other diseases, as well as the nature, extent, and immediate consequences of the attack, ought in great measure to be considered before making a diagnosis.

Sometimes mental symptoms, such as delirium or excitement with hallucinations, are found intercurrent with the stupor and coma following the shock, and the condition may gradually become very similar to that of primary dementia. As a general rule, however, although there may be some trace left of the primary injury to the brain, the prognosis is more favourable in such cases than when the psychosis develops some months, or even years after the injury.

The possession of an unstable nervous system is attended by a peculiar liability to easily succumb to the effects of heat. The writer has seen several cases of syncopal attacks, and even of an asphyxial character, occurring in imbeciles after exposure to a hot sun for a few hours, and their exceeding proneness to be affected in this manner renders it necessary to exercise care that they are not exposed unduly during the hot months. Epilepsy is one of the most common of the sequelæ of insolation, and occurs in various degrees of severity, from slight epileptiform convulsions to the severest forms of the disease. Sometimes the epileptiform or apoplectiform seizures of general paralysis of the insane have been mistaken for sunstroke. The frequent occurrence of epilepsy is suggestive, and, as in the cases of periodical psychoses already mentioned, the disorder appears to be a manifestation of an unstable vaso-motor state.

Both idiocy and imbecility may be dependent upon early epilepsy, but the absence of spastic symptoms, contractures, and other deformities, together with the absence of progressive deterioration associated with the convulsions, are characteristic of an acquired rather than a hereditary state; and in epilepsy following upon sunstroke, the mental defects and convulsions are collateral phenomena, both depending upon the same cause, whilst the positive signs of alienism, such as anomalies of character and moral perversions, with defective or one-sided development of special faculties, all point to an acquired psychosis, in a great measure differing from the progressive deterioration of ordinary idiopathic or hereditary epilepsy.

In adults episodical attacks somewhat analogous to epilepsy occur; thus there may be a periodical attack of depression, maniacal delirium, or even conditions closely resembling the maniacal, epileptiform seizures of paretic dementia.[1]

Meningitis is sometimes ushered in by vertigo, or convulsions, or epileptic seizures. In the later stages the occurrence of coma is very frequent. The symptoms are so well known that they need be but briefly referred to here. In the early stages hyperæsthesia, tremors, photophobia, illusions, and in children the characteristic hydrocephalic cry, are generally present. Later these symptoms are followed by drowsiness and apathy, or there may be delirium or paralysis of various forms.

In the third stage there is anæsthesia, and coma may supervene. Paralysis becomes more pronounced, and convulsions increase in frequency and severity as the fatal end approaches. Sometimes the patient is able to rouse himself from the coma for a few days, but almost invariably a relapse occurs. Drowsiness, coma, and collapse may be the only indications of what proves to be extensive meningitis. The symptoms are sometimes very similar to delirium tremens. The diagnosis of a tubercular origin must depend upon careful attention to the history of the patient. Profound coma is more liable to occur when the lateral ventricles are distended with fluid, and their parietes softened and compressed.

Apoplexy, with effusion of blood between the cranium and dura mater, or from the subarachnoid tissue, or into the substance of the brain, may be due to lacerations from violence or rupture of diseased vessels. The attack usually comes on suddenly and unexpectedly, and there may be premonitory symptoms of local disturbances of the cerebral circulation. Of these symptoms the most important are numbness or tingling, loss of power, diplopia, and signs of paralysis. These symptoms, however, may be purely functional, or indicative of the presence of a tumour or other circumscribed lesion. When actual effusion of blood has taken place the patient becomes aware of pain in the head and sudden giddiness followed by paralysis, or there may be syncope passing into coma and paralysis when the hæmorrhage begins in the external capsule (Broadbent). Sometimes the attack is ushered in by convulsions followed by coma. The symptoms vary in severity very considerably according to the extent, nature, and locality of the lesion. When coma supervenes the patient is sometimes capable of being roused, but soon he becomes utterly unconscious. The pupils may be natural, irregular, and insensitive to light, contracted when the hæmorrhage is into the pons, or dilated especially towards the fatal end.

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[1] "Lectures on the Diagnosis of Insanity," by Theo. B. Hyslop, *Med. Press*, February 1896.

The occurrence of coma implies either a large effusion of blood or effusion into some vital part. Effusion into the pons is usually attended by convulsions and profound coma and paralysis, especially if the hæmorrhage is great in extent. Hæmorrhage into the cerebellum is attended by severe occipital pain, vomiting, etc., and giddiness rather than actual loss of consciousness.

Thrombosis and embolism, causing obstruction of one of the cerebral arteries, is attended by symptoms closely resembling apoplexy, and, as in apoplexy, the characters of the symptoms vary according to the size and distribution of the vessel affected. In embolism the obstruction almost invariably occurs in the middle cerebral artery, or one of its branches, and is attended by more or less complete hemiplegia, etc. The prognosis is usually unfavourable, and seldom are the effects of thrombotic or embolic softening completely recovered from. When consciousness is interfered with the intellect is apt to fail until dementia supervenes. Coma is more strikingly characteristic of hæmorrhage than plugging.

Tumours in the brain are usually attended by vertigo, headache, vomiting, paralysis, convulsions, and spasms, and various intellectual and emotional disorders. The convulsions may be epileptiform, but unlike true epilepsy, unattended with loss of consciousness, or later unconsciousness may come on. Sometimes the earliest indications of cerebral tumour may be momentary attacks of incoherence, aphasia, or loss of consciousness, or attacks stimulating hysterical fits or apoplectic seizures. Failure of memory and mental hebetude go on to fatuity and dementia. The diagnosis of the site of a tumour must depend upon anatomical and physiological considerations, and the pathological nature of the growth upon other considerations, such as arise in connection with tubercle, syphilis, aneurysms, malignant growths, and hydatids.

Functional disturbances of the brain may be evidenced by drowsiness, epileptiform or apoplectiform seizures, or coma. The modes of onset differ somewhat from those due to effusion of blood, in that the paralysis is more general and attended with flaccidity, acceleration of the pulse, and rise in temperature.

These comatose attacks occur in association with lateral and disseminated sclerosis, occasionally in children, and simulating meningitis, and especially in general paralysis of the insane.

The congestive seizures occurring in general paralysis of the insane may be epileptiform or apoplectiform in character. Epileptiform seizures vary in severity from *petit mal* to *epilepsia gravior.* They may occur at any stage of the disease, but more commonly they occur when the disease is advanced. A succession of seizures results in the *status epilepticus* well known to all asylum physicians. Sometimes with even severe epileptiform seizures consciousness is retained. The number of seizures may amount to several hundreds daily.

Quasi-syncopal attacks are also not uncommon. Apoplectiform seizures may occur with or without convulsions; they are less frequent than the epileptiform, and may or may not be attended by temporary paralysis, of which the most common is a partial or incomplete hemiplegia. Various simple paralytic seizures also occur, but almost invariably the paralysis clears up and vanishes in a few days.[1]

Auto-intoxications[2] may occur from suppression or disturbance of the functions of an organ. Affections of the various glands, with or without pathological lesions, may give rise to symptoms which are attended by or culminate in loss of consciousness. Myxœdema, cachexia strumipriva, diabetes, acute yellow atrophy of the liver, and Addison's disease, may be productive of attacks varying from partial loss of consciousness to complete coma. Gout and oxaluria, etc., depend upon absorption of faulty products of metabolism, and may be attended by affections of consciousness. In carbonic acid poisoning, uræmia, and eclampsia gravidarum, the products of metabolism are apt to be retained in the different organs. Huppert arrived at the conclusion that albumin appears in the urine after every well-marked fit of epilepsy, and the more severe the fit the more abundant the albumin. Mere cases of epileptic vertigo may be quite unattended by this phenomenon unless the attacks follow one another rapidly. Albuminuria is more common in paralytic insanity than in any other cerebral disease. De Will found albuminuria after the convulsions of general paralysis, while König, Richter, and Mendel, on the other hand, usually found it absent. The writer[3] has elsewhere stated that renal disease is associated with affections of consciousness in two ways: (1) acute transient delirious mania, an acute toxæmia, or uræmic insanity; and (2) a progressive cerebral degeneration, with chronic renal disease as the primary cause. In this latter type the mental symptoms during the earlier stages vary from a mild dementia to mania or delirium. In due course, however, complete dementia, not unlike that of general paralysis, results. The writer has seen many cases of mania with excitement and even delirium, in which the pupils were contracted, reflexes diminished, muscular tremors, and convulsive attacks with loss of consciousness, due to an over-production of toxic substances in the body and eliminated in the urine. The dyspnœic and gastro-intestinal forms of uræmia are sometimes seen in the insane, but it is with the comatose and convulsive types that asylum physicians have mostly to do. Other auto-intoxications, due to the over-production of physiological and pathological products of the organism, are (Van Giesen) hydrothionæmia, ammoniæmia, acetonuria, diaceturia, cystinuria, etc., also diabetic coma, coma carcinomatosum, etc., and Basedow's disease.[4] Malaria is sometimes attended with or followed by extreme collapse, coma, or delirium, epileptiform or tetanoid convulsions, or various mental symptoms. Simple uncomplicated attacks of malaria are rarely followed by such affections; but when the nervous system has been weakened by syphilis, alcohol, and various excesses, not only is some neurosis likely to supervene, but it is likely to be of a serious, intractable nature. Simple cases, where no other factor than malaria has been present, generally recover.[5] (For an account of the various alterations of consciousness occurring in association with or following various fevers and bodily diseases the reader is referred to the article on

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[1] See "General Paralysis."

[2] Van Giesen, *States Hospital Bulletin*, vol. i.

[3] "On the Mental Conditions associated with Bright's Disease Uræmia," *Practitioner*, November 1901.

[4] See also article "Urine," Tuke's *Dictionary of Psychological Medicine*, by Blyth and Hyslop.

[5] Hyslop "Malaria," *Dict. Psych. Med.* p. 756.

"Post-Febrile Insanity" by the writer, in Tuke's *Dictionary of Psychological Medicine.*)

Drugs are productive of loss of consciousness and severe or fatal coma. Of these drugs the following must be referred to briefly:—

Alcohol may cause convulsions, epileptiform or apoplectiform seizures with coma. In mania due to alcohol convulsions may be so severe as to lead to a fatal result from syncope or coma. The occurrence of these seizures, together with inequalities of the pupils and various indications of paralysis, have frequently led to a faulty diagnosis of general paralysis. The apoplectiform, or more particularly the epileptiform attacks, differ in certain respects from those occurring in general paralysis, and the pseudo-general paralysis due to alcohol generally ends in recovery.

Lead poisoning is also sometimes attended by not only a progressive physical and mental decay, but also by acute delirium or convulsions which may prove fatal. The various epileptic or eclamptic disorders due to lead are apt to be followed by dementia and symptoms which have been mistaken for those of general paralysis, and to these cases the term saturnine pseudo-general paralysis has been applied. When the cases progress unfavourably the end is usually due to convulsions and coma. Other intoxications due to morphia, cocaine, absinthe, ether, chloral, haschisch, tea, nicotine, oxide of carbon, are commonly met with, and may be characterised by vertigo, syncope, delirium, epileptiform or apoplectiform seizures, or other derangement of consciousness.

Lastly, unconsciousness may be induced artificially by hypnotism (see article "HYPNOTISM"), or by anæsthetics.

Undulant Fever.

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SYNONYMS.—Mediterranean, Malta, rock, Cyprus, Neapolitan, Cretan, etc., fever, from its geographical distribution; intermittent typhoid, recurrent typhoid, typho-malarial, etc., from its resemblance to typhoid fever; gastric remittent, bilious remittent, or simple remittent fever, from its remittent character; simple continued fever from its lengthened course and want of definite symptoms.

Definition.—A pyrexial disease, endemic in certain localities, having a long and indefinite duration, with a tendency to undulatory waves of temperature.

HISTORY.—There is very little doubt that Hippocrates in his *Epidemics*, about B.C. 450, described this disease. The next accounts of this fever that are in any way reliable we get from French military surgeons during the French occupation of Malta (1798-1800).

During the earlier part of the nineteenth century we get numerous accounts of this fever by naval and military surgeons serving in the Mediterranean, which are chiefly of interest in showing the extreme difficulties they experienced in classifying the fevers they met with. In the writings of Sir Wm. Burnet (1810), Henner (1818), Davy (1842), Marston (1860), and Notter (1876), this fever is undoubtedly recognised and described, but it is not until 1879 that we get any stress laid on the fact of this being a separate disease, *sui generis*, when Veale published a paper in the *Army Medical Report* of that year. From 1879 to 1889 nothing of importance was published about this disease, but in the latter year Bruce published an account of this fever in the *British Medical Journal*, which at once brought this disease out of the general confusion surrounding febrile conditions occurring in the Mediterranean, and established it as a separate specific disease.

GEOGRAPHICAL DISTRIBUTION.—The chief objection to the names Mediterranean or Malta fever for this disease (the terms by which it is generally known) is that it undoubtedly occurs in many other places besides Malta and the Mediterranean ports. It is certainly endemic in Malta, Gibraltar, Crete, and Cyprus; probably also in Italy (southern portion), Greece, Turkey, and Sicily. There is now very good evidence that it occurs also in India, North and South Africa, South America, Straits Settlements, and China. The author has no doubt that when this disease is more generally understood, it will prove to have a very wide distribution, as he has been shown cases of so-called typho-malarial fever in the Straits Settlements, Borneo, and China which, with his present knowledge of the disease, he would have no hesitation in calling undulant fever.

ETIOLOGY.—The discovery by Bruce in 1886 of the micrococcus Melitensis in the spleen of cases suffering from this disease finally established its causal agent. How this organism enters and leaves the human body, or what its habitat outside the human body may be, are up to the present unsettled points.

Theories with Regard to Causation.—(1) The popular theory of the causation of undulant fever in Malta where, it may be mentioned, practically all the research work on this subject has been done, is that it is caused by the insanitary condition of the tideless harbours of that island.

(2) Hughes, in his work on this fever, inclines very strongly to the theory that the disease is caused by an aerial fæcal poison.

(3) The latest and at the present time most popular theory, at any rate in Malta, is that it is caused by the sting of some infected insect, such as the mosquito or sandfly, in exactly the same way as malaria is.

From the evidence the writer has been able to collect during the past three years from naval, military, and civilian sources in Malta, there are insuperable difficulties to acceptation of any of these theories.

The matter is still unsettled, but from the work on this subject that has been done up to the present the writer has come to the following conclusions:—

(*a*) That the disease is air-borne. This is arrived at by a process of exclusion of the other possible sources of infection, such as water, food, bites of insects, etc. (see Bacteriology).

(*b*) That it is a very widely diffused organism in the localities where the fever is endemic, *e.g.* Malta. This conclusion is drawn from the fact that it occurs practically all over the island, attacking people living under totally different sanitary and social conditions.

(*c*) That it has to be taken into the healthy individual in a large dose to produce its characteristic effects.

By this is meant that in all probability the dwellers in an area where this fever is endemic inspire in the air they breathe a certain number of the organisms producing the disease, and that the natural bactericidal power of their blood is sufficient to destroy the organisms thus taken into the system, but that granted (1st) a lowered bactericidal power from any cause, such as excessive fatigue, chill, the effects of some other illness, noticeably influenza and pneumonia, etc., or (2nd) that the organisms are taken into the system in sufficient quantities and for a sufficient length of time to overcome the natural bactericidal powers of the blood, then the organism gets the upper hand and finds its way to the spleen, and there is as much difficulty in dislodging it as it has found in arriving at its suitable nidus.

There are many facts that point to the probability of this theory being correct. The fact that the Maltese population (still taking Malta as an example) suffers in much smaller proportion than the European, points to their having a much stronger bactericidal power towards the organism, partly hereditary and partly acquired, the last being probably due to the fact that from earliest childhood they have been taking small doses of the organism into their system, and so increasing their bactericidal power towards it.

It is also a fact that individuals recently arrived into an endemic area are more liable to contract the disease than people who have resided there for some time, showing that a partial immunity is acquired by length of residence in the infected area.

Influence of Age.—Children under four years of age and old people are seldom attacked, but people of all other ages seem equally prone to attack.

Influence of Season.—The fever is usually most prevalent in the months of May, June, July, and August, the period of lowest rainfall, and what the writer would lay stress on, the period of greatest variability in the direction of wind with frequent dust storms.

Incubation Period.—The exact incubation period of a disease usually starting with very indefinite symptoms is difficult to settle, but the evidence collected on this subject points to the fact that from ten to sixteen days is the usual incubation period. In the cases of accidental inoculation with the mic. Melitensis, of which several have now occurred, the incubation period has varied from five to fifteen days.

Not Infectious.—In spite of the popularity of the recent mosquito theory of its origin, the writer is convinced that it is not directly communicable from the sick to the healthy.

Immunity.—One attack usually confers immunity, just as is the case with most specific diseases. There has been much controversy on this subject, but the evidence obtainable since more accurate diagnosis has been established practically puts this fact beyond any doubt.

Prophylaxis.—Avoidance of the infective areas during the months of the year when this disease is most prevalent.

Attendance to the ordinary hygiene of everyday life would prevent many attacks if the writer's theory with regard to the distribution of this organism is correct. The histories of such a large proportion of these cases give some hygenic indiscretion prior to the attack, the commonest being (*a*) getting a chill after taking violent exercise; (*b*) sleeping in cotton garments, which become saturated with perspiration; (*c*) being out in a hot sun all day, and returning in the cool of the evening without additional wraps; (*d*) over-fatigue, followed by sitting about in cool draughts; (*e*) drill or other hard work on an empty stomach; and many other indiscretions of a like nature.

Better sanitation of most of these localities is urgently required, as tending to improve the general health, but people living under what are apparently perfect sanitary conditions are still attacked by this disease.

PATHOLOGY. — *Morbid Anatomy.* — The opportunities for working out the pathology of this disease, in spite of its frequency in the endemic areas, are very few. This is owing partly to the fact of its very low mortality.

In the cases that die during an acute attack of fever the only morbid changes noticed were confined to the following organs:—

Heart. — Very pale and flabby. The walls thinned, and showing marked degeneration of the muscle fibre; no endocarditis or pericarditis; in some cases the heart walls become so thinned as to be almost transparent when held up to the light.

Lungs.—Usually a little passive congestion of the bases, secondary to a failing heart.

Liver.—Congested and increased in weight. Average weight 58 oz.

Spleen.—Much enlarged, very soft, and in some cases the spleen pulp quite diffluent, running out like semi-fluid blood when the capsule is cut into. The capsule of the spleen is thickened and tough. Average weight 19 oz.

Brain.—Usually congested, with slight increase of fluid in ventricles, but often quite normal in appearance.

Kidneys.—Sometimes slightly congested, but usually normal in appearance and weight.

Alimentary Canal.—Has always been found quite normal from mouth to anus in the cases examined by the writer.

In cases which die late in the disease, usually from heart failure or intercurrent diseases, there are the signs of long-continued toxic irritation of the tissues. The liver and spleen, but more especially the latter, are both enlarged, but firm to the touch and with excess of fibrous tissue in them. The heart is usually very pale, with thin walls and often dilatation of the cavities.

Microscopic Changes.—The only changes that have been observed microscopically, apart from those produced by long-continued toxic irritation of the tissues, have been in the spleen, liver, and kidneys. Sections of the spleen show an increase in the lymphoid tissue, with enormous numbers of single micrococci scattered through the section. The liver cells are found to be in a condition of cloudy swelling, and show granular degeneration of their protoplasm. The kidneys show the same changes of granular degeneration of the glomeruli.

BACTERIOLOGY.—The micrococcus Melitensis is a minute, oval-shaped coccus, occurring generally singly, sometimes in pairs, but never forming chains. It measures about 33 mm. in diameter (Bruce), and when examined in the hanging drop shows rapid movement. Gordon states that it is provided with from one to four flagellæ, and the character of its circular movements in the hanging drop certainly suggests the possession of flagellæ. It stains well with the more powerful of the aniline dyes, but very rapidly loses its stain. It does not stain with Gram's method.

Growth Characteristics.—It is a very slowly growing organism, usually taking four days to make its appearance on suitable media. The degree of alkalinity of the media employed is a matter of great importance to this organism. It grows best on gelatine, agar, or in bouillon of an alkalinity of − 10 (Eyre's method); it can be educated to grow on media of a greater alkalinity, on neutral media, and even on faintly acid media, but the growths are feeble and take many days to appear. Many disappointments will be met with in working with this organism, if this extreme susceptibility to the reaction of media is not constantly borne in mind. The shortest time in which the writer has been able to obtain a growth was forty-six hours, on agar of a very suitable alkalinity inoculated direct from the spleen. In liquid media slight turbidity shows about the fourth day, the medium never becoming more than slightly opaque, as the growth settles to the bottom of the tube in a thin flaky deposit. No pellicle is formed.

On solid media the colonies appear as minute, circular, clear growths, like little drops of sweat coming out on the surface of the medium; in four to five days these drops assume a pale amber colour, and later on become somewhat opaque, though even in quite old growths there is still a considerable amount of translucency. No liquefaction of media or formation of gas occurs.

The optimum temperature for this organism is 37° C. to 38° C., but it will grow well at any temperature between 20° and 40° C. This micrococcus will retain its vitality after a considerable amount of drying.

PROGNOSIS.—The prognosis, as regards life, in undulant fever is extremely good, as the mortality from this disease is under 2 per cent, but the prognosis as to length of attack is very uncertain. It may be taken as a general rule, that, in cases commencing with one or two high waves as fever, and generally acute symptoms, with a serum possessing a high agglutinating reaction, the attack will be of much shorter duration than in cases with either the remittent or low type of fever. It must, however, be remembered that a case may suddenly or gradually change its type of fever, and it is quite common to have temperature charts showing all three types of fever at different periods of the same attack.

The tongue is a very good guide as to prognosis, because as long as it remains lightly furred, flabby, and slightly enlarged, the patient is always liable to relapse, even if he has been for two or three weeks with normal temperature, but once the tongue really clears up and assumes its healthy aspect, then it is pretty safe to say that the patient has really got rid of his fever.

Much disappointment is met with in practice from want of attention to this guiding principle, as patients are frequently sent back to their duties, after that their temperature has remained normal for a week or two, as cured, only to return to hospital with relapses in any time from a few days up to three months. In the author's opinion these cases have not got rid of the organism from the spleen, where it remains quiescent until such time as the bactericidal power of the blood is again lowered sufficiently in some way, *e.g.* excessive fatigue, etc., to allow the organism to once more get the upper hand, when the unfortunate patient again has to go through many weeks or months of fever just as if it were a fresh attack.

DIAGNOSIS.—The diagnosis of undulant fever in its early stages, where Widal's test is not available, is an extremely difficult matter. This is owing to the fact that it commences in so many different ways; in some cases continuous high fever (averaging 104°) with intense headache, diarrhœa, distended abdomen, enlarged spleen, and in fact simulating enteric fever in all its signs and symptoms; in others a continuously low temperature, varying from 99° to 100°, often never going above 101° with practically no other symptoms; in others, again, a high temperature for two or three days, 103° to 105°, with congested tonsils and fauces, furred tongue, and headache, the temperature dropping to 99° or 100° at the end of three or four days and continuing indefinitely at that range.

In its early stages this fever may be mistaken for almost any disease that commences with raised temperature and general malaise; those with which it is most usually confounded being enteric fever, rheumatism, acute tonsillitis, acute tuberculosis, and what, for the want of a more accurate term, is known as simple continued fever, or simple febricula. It is a matter of frequent occurrence to get cases sent into hospital as undulant fever which turn out to be tubercle, subacute rheumatism, deep-seated abscess, malaria, or secondary syphilis.

Latterly the serum test for this fever has been much more widely used in the endemic areas, with the result that there is some accuracy about the statistical returns of the various fevers, whereas before Widal's test came into popular use for this disease the statistical return of fevers was totally unreliable.

The sedimentation or agglutination test with the serum of cases of undulant fever is extremely reliable and satisfactory in every way. The reaction is nearly always obtainable by the fourth day of raised temperature, sometimes earlier and seldom later than the sixth day. It is also obtainable in much bigger dilutions than is the case with B. typhosus.

The writer, after having had very large numbers of these cases under his care, has found that a dilution of one in fifty with a time limit of half an hour for the agglutination test is a reliable, easy, and rapid method of applying the test for this disease. In doubtful cases this test should be supplemented with varying dilutions and the sedimentation test.

The serum test is also very useful from a prognostic point of view. Cases with high agglutinating powers usually making a more rapid recovery, especially if the agglutinating reaction gradually increases as the disease progresses; on the other hand, if the agglutinating power is low or gradually diminishes during the course of the disease, it usually means a very long illness, though not necessarily of a severe type. The writer has also observed that with a rising wave of temperature the agglutinating power also rises, and that it generally goes on rising for a day or two after the temperature wave has reached its extreme height and has already begun to come down.

SYMPTOMS.—Undulant fever is a disease remarkable for the fewness of its symptoms, a large proportion of the cases having practically no symptoms beyond the raised temperature, so that the question of pyrexia in this fever will be dealt with first.

Pyrexia.—The most noticeable points about the temperature charts of these cases are their extreme length, the variety of types they assume, and the tendency underlying the various types to produce undulatory waves of fever.

The duration of the pyrexia, and the various types the chart may assume during the course of the attack, are both quite indefinite, and appear to follow no rule that can be made applicable to even a majority of these cases.

The remittent type of chart is by far the commonest, but there may be a continuously high run of fever, or a long continued low pyrexia, there may be remissions or there may be none, and the type of pyrexia may vary during the course of the attack, so that all three of these types may be produced in different parts of the same chart.

A glance at the accompanying charts, which are selected from many hundreds of cases, will show much more clearly than any written description what is meant by the different types of pyrexia met with in this disease.

The chart A is typical of the remittent type of fever. This type of the disease usually lasts a very long time, is accompanied by the more severe forms of neuritis, the sweating during the night is excessive, but patients feel comparatively well all day and take food well.

The chart B is typical of the continuously low form of pyrexia. These cases seem quite unaffected by treatment, do not as a rule suffer from neuritis, keep up their weight if generously fed, but seldom get rid of their disease without change of climate.

The chart C illustrates a case, starting with continuously high form of pyrexia, lasting for nearly three weeks, and then taking on the remittent type.

It is in this type of the disease that it is almost impossible, at any rate at the commencement of the illness, to make a diagnosis between undulant and enteric fever, without examination of the serum for Widal's reaction. These are the cases which have diarrhœa, distended abdomen, a large liver and spleen, with foul tongue and delirium. The enteric spots are of no value as a diagnostic help, as many cases of enteric, in tropical and subtropical climates, have no spots, and many cases of undulant fever have spots which may easily be mistaken for enteric spots, both by their appearance and the fact of fresh ones appearing day after day.

The chart D illustrates in a very marked manner the waves of pyrexia from which this disease derives its name. It is not very common to have such definitely marked waves, but this undulant character will be found in every type of the pyrexia of this disease.

Alimentary System.—The fauces and tonsils always show signs of more or less congestion, or even inflammation, in the first few days of the illness, with occasional enlargement and tenderness of cervical glands.

The tongue is furred; in acute cases a thick, dirty fur covering the whole tongue, in mild cases a light fur on the posterior half of the tongue, with the edges and anterior portion moist and clean. The tongue may be denuded of its surface epithelium in the acuter cases, and assume the glazed, raw ham appearance. In the later stages of all types of cases, provided they are under appropriate treatment, the tongue gets an appearance which is very typical of this disease—the whole tongue slightly enlarged and flabby, with tip, edges, and anterior portions moist and clean, but posterior portion lightly furred and moist, with transverse striation.

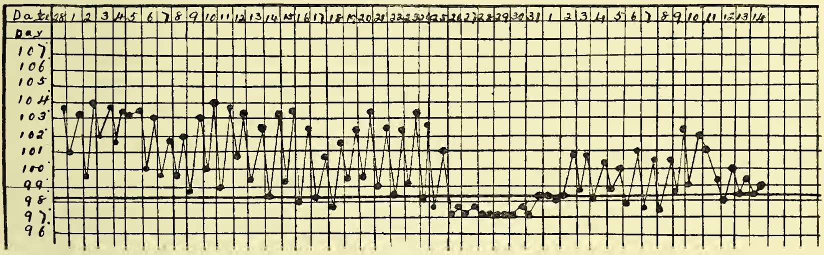

Chart A.

These transverse striæ sometimes go quite deep into the surface epithelium, and look like cracks. There is often slight epigastric tenderness during the first few days of fever, but very rarely any vomiting.

Constipation is the general rule in this fever, though during high waves of temperature it is not uncommon to get diarrhœa with loose yellow motions.

The appetite is poor for the first few days until the intestinal tract has been cleansed with purgatives and intestinal antiseptics, after that it is remarkably good, the patient suffering from this disease being able to digest solid food extremely well, even when their temperatures are running fairly high.

The liver and spleen are both always enlarged, especially the spleen. During the height of a wave of fever the spleen is tender, enlarged, and very soft, hardening again as the temperature comes down.

Epistaxis is by no means uncommon in this disease, occurring in 6 per cent of the writer's cases. Nearly always it comes on at the height of a wave of fever, is severe as a rule, and the temperature usually goes steadily down after it.

Tegumentary System.—Sweating is usually profuse, especially in cases with the remittent type of chart; at the height of a wave the skin remains hot and dry, but when the temperature is falling the patient is bathed in perspiration every night.

The hair gets dry and brittle, and frequently falls out to a great extent. In cases of long illness the nails also get brittle and break easily.

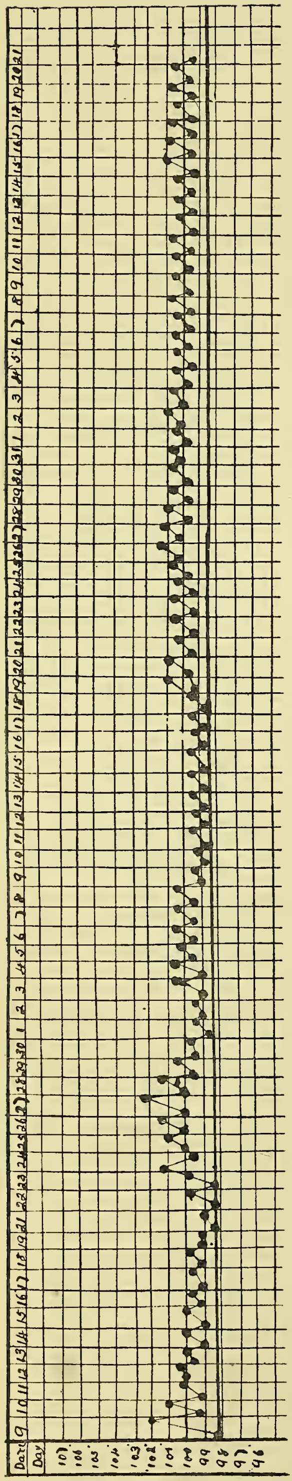

Chart B.

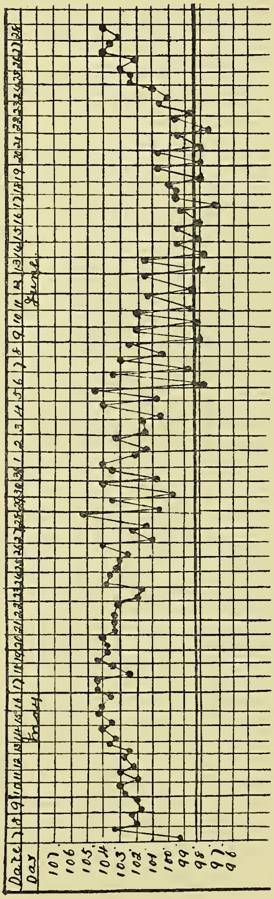

Chart C.

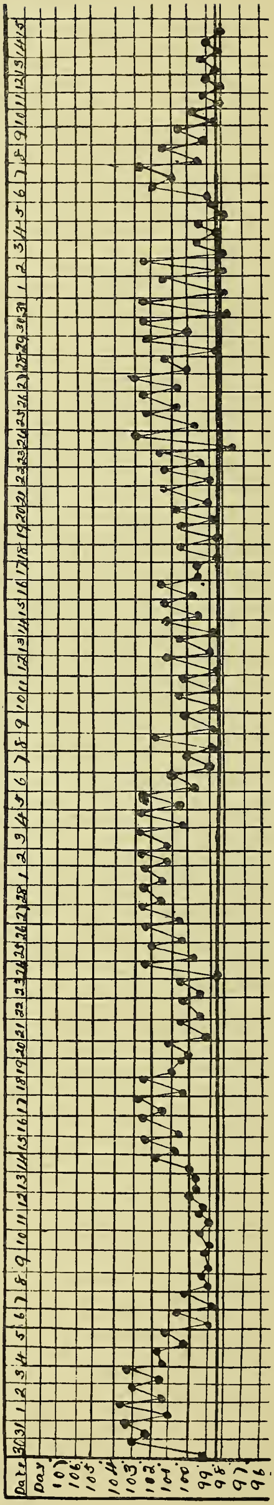

Chart D.

The profound anæmia of the long cases of undulant fever, though always described, is very rarely seen in patients that have been kept throughout on a generous diet. In the same way subcutaneous hæmorrhage or purpura, though apparently extremely common two or three years ago, are now scarcely ever seen.

Nervous System.—Next to the pyrexia the writer would place affections of the nervous system as the most common symptom of this disease; a neuritis, more or less severe, occurring in quite half the cases. The nerves especially affected are the sciatics, circumflex, and peroneals, named in the order of frequency, although almost any nerve may be attacked. This neuritis comes on quite suddenly, is usually acutely painful, preventing any voluntary movement of the affected limb, and pressure along the course of the affected nerve being almost unbearable.

The acuteness of the symptoms passes in twenty-four to forty-eight hours, but a subacute neuritis of the nerve is usually left, which may continue, varying in severity from day to day, but often lasting, with remissions, throughout the course of the fever, and sometimes for many months after the fever has quite subsided. There is no doubt that the products of this micrococcus seem to have a special and selective action on the central and especially the peripheral nerve tissues, and also probably on the fibrous sheaths of nerves. Their localised and metastatic nature, the fact that they often persist for months after the subsidence of the fever, and the severity of the pains at the back of the neck, in the lumbar region, at the back of the eyeballs, the mental irritability and the wakefulness, all point to this virus having a special action on the cerebro-spinal system.

In severe cases with high temperature an active form of delirium is usually present, and at the end of a long attack of fever there is considerable nervous prostration with impairment of mental capacity. Irritability of the nervous system is also shown by an increase in the reflexes and cutaneous hyperæsthesia over certain spots supplied by specially affected nerves.

The importance and frequency of this neuritis has not been sufficiently noted in the literature of this disease, whereas, on the other hand, much is written about the frequency of arthritic symptoms, Hughes stating that effusion into joints occurs in 40 per cent of the cases.

Arthritic Symptoms.—In the writer's experience effusion into joints is extremely rare. It is common to hear that a patient with this fever is "crippled with rheumatism," but on examination of the case it almost invariably turns out that the patient is crippled with neuritis, there being no effusion into the suspected joint or joints.

Effusion into joints, however, does occur; in the writer's cases in under 1 per cent. of the total cases. It usually takes the form of a chronic or subacute effusion which takes a considerable time in getting absorbed, and is quite unaffected by the administration of salicylates. The knee is the joint most commonly affected.

A passive effusion also occasionally occurs into tendon sheaths, the extensor tendons at the wrist and the tendon Achillis being the ones the writer has seen affected.

Circulatory System.—The only special point about the circulatory system in this fever is that the nerves of the heart are affected in the general nerve disturbance, causing an increased rate of heart's action, not at all in proportion to the degree of fever; also palpitation from the most trivial causes is common. A patient who by his temperature chart appears to be having a not at all severe attack of fever, may really be in much greater danger from heart failure than a case with severe symptoms and high fever. The implication of the nervous vaso-motor system in this disease must always be kept in mind in the treatment of cases. The few deaths the writer has seen from this disease have all been caused directly by heart failure, and at the post-mortem examination the muscle fibre of the heart has been found thin, pale, greasy, and acutely degenerated.

Urinary and Sexual Systems.—The urine is usually normal, except during periods of high fever, when a trace of albumen may be present. The fact of retention of urine being likely to occur in acute cases must always be kept in mind.

Epididymitis and orchitis are fairly common complications in this disease, not usually of a very acute or painful type, and soon subside with rest and warmth.

Complications.—Hyperpyrexia may occur; it is usually easily controlled with ice-packing, but cases sometimes are very stubborn to any form of external cold application or antipyretic drugs. The best guard against getting hyperpyrexia is to have a routine rule for external application of cold whenever the temperature goes above 103·6 degrees.

Cardiac failure is the great complication to be guarded against in the writer's opinion. It must be remembered we are dealing with a fever of very long duration, and not only that, but a fever in which the nervous apparatus of the heart is often seriously involved, and our treatment must be directed towards keeping the heart muscle in as good condition as possible for the long continued extra work that is thrown on it.

Pulmonary congestion often occurs, but is secondary to a failing heart. Pleuritic and pericardial effusions are said to occur, but the writer has not met with them.

TREATMENT.—It may be at once stated that no drug has any specific action on the course of this fever, although almost every drug in the Pharmacopœia, and a good many not in it, have from time to time been vaunted as specifics.

In the treatment of cases of undulant fever there are three main points to be kept in mind, viz. (1) that the patient is suffering from a febrile disease, which is probably going to last for many weeks or even months, (2) that it is of the utmost importance that the patient's temperature should be regulated for him; and, lastly (3) that the heart should be assisted in its work by every possible means, as not only does the poison of this coccus affect the muscle-fibre of the heart itself, but it seems to have a specially deleterious influence on the cardiac nerve-supply.

The statement is often made that there is no treatment for undulant fever, and yet there are few diseases in which more can be done to ameliorate the patient's condition, by a careful attention to detail, and by basing the treatment on the three above-mentioned guiding principles.

At the commencement of the attack the patient should be kept in bed, clothed in flannel because of the profuse sweating, and given a purgative. It is usual to prescribe some form of febrifuge mixture or an intestinal antiseptic; the writer has found Burney Yeo's chlorinated quinine mixture the most suitable.

After the first few days it will be seen what sort of a course the temperature is likely to run, and the treatment will vary somewhat accordingly. The medicinal treatment of this disease consists essentially in keeping the intestinal tract clean and in a fit condition to digest and absorb food. Purgatives are required in the majority of cases, and a dose of ordinary sulphate of magnesia mixture taken the first thing every morning is a good routine treatment.

Treatment of the Pyrexia.—This is a point to which special attention should be given all through the disease, and there is no doubt that the most satisfactory results are obtained by lowering temperature by the external application of cold, either sponging with ice-cold water, ice packing, or ice suspended in buckets on a cradle over the patient's body. The administration of the usual antipyretic drugs—such as phenacetin, antifebrine, antipyrine—should be discouraged as much as possible in this disease, because of their depressant action on the circulation, as, where a patient's temperature is probably going to run up to unsafe limits very many times during perhaps very many weeks, it means very constant dosage with depressants of the circulation.

The external application of cold should be made use of systematically and not spasmodically, as when the patient's temperature has run up to 105° or 106°. The best system is to apply cold whenever a temperature goes above 103·6°, to bring the temperature down to about 101°, and then cease application of cold. The principle underlying this treatment is to prevent as much as possible the temperature getting to the heights where it throws excessive work on the circulatory system. If this system is adhered to throughout an attack of such a prolonged disease, the amount of work thrown upon the various organs of the body, and the amount of cellular wastage and general tissue irritation, must in the aggregate be enormously diminished.

In some cases of high fever the external application of cold will not bring the temperature down, even if continued till the patient's skin is blue and cold. In these cases, before having application to antipyretic drugs, the writer has often found that the administration of a copious enema, a pint and a half to two pints of ice-cold water, will have the desired effect of bringing down the temperature. Failing these measures recourse must be had to drugs, and of these phenacetin in five-grain doses is by far the most reliable. The writer made many experiments with the various antipyretic drugs in this disease, having the temperatures taken hourly for ten hours after the administration of a dose, and found that phenacetin acted most regularly and constantly, its effect on the temperature usually being perceptible for much longer (averaging seven hours), and its depressant effects on the circulation being less than in the case of other drugs.

The treatment of the neuritis in this disease is on the whole extremely disappointing. When acute, the application of warmth gives the most relief, when subacute or chronic, the administration of salicylate and iodide of potash, small blisters along the course of the affected nerve, inunction with iodide of potash ointment, and a lot of other remedies, appear in some cases to do good, in others to have no effect at all.

For the cardiac weakness and irritability strychnine gives the best results, but should be administered early, and not left till the heart is beginning to show signs of failure. The writer has found that it gives much more satisfactory results if given hypodermically, either once or twice daily for a few days, then omitted for a few days, and so on, according to the condition of the heart, than if taken by the mouth in the usual mixture.

The real treatment of undulant fever consists in keeping the patient in such a condition that he will avoid many of the symptoms of the disease, especially the anæmia, the cardiac weakness, and the neuritis, and this can be done by feeding the patients properly, and so keeping up their strength, weight, and spirits.

Two or three years ago the ordinary, and, in fact, universal dietary for these cases, was a fluid diet consisting of beef-tea and milk. It was supposed that solid food, even in the smallest quantity, such as a few grains of rice in the patient's soup, at once made the temperature rise. The only reason why this idea could have lasted so long, was the ever-present fear in the mind of the practitioner that he might be dealing with a case of enteric, as until the Widal test came into general use there was often every excuse for the most accomplished diagnostician, being quite unable to decide whether he was dealing with a case of undulant or enteric fever.

Now the effect of keeping cases, with pyrexia, lasting often continuously for months, on a diet of beef-tea and milk only, and constantly in bed, can hardly be imagined by any one who has not happened to see them. The patients are anæmic, emaciated, and listless, taking no interest in whether they get better or not, often with œdema of legs and feet, purpura, and even bedsores.

The sight of wards full of these miserable objects started the writer on a series of dietary experiments, with the result that the "generous diet" treatment is becoming very generally adopted in Malta, at any rate, by the naval and military medical officers on the station.

It is remarkable how well cases of undulant fever will digest solid food, even with their temperature running fairly high. This is, in fact, one of the diseases where we may trust a good deal to the patient's own feelings in the matter of his dietary, and give him an ample diet when he declares himself equal to taking it. The writer's routine is to keep patients in bed for the first two or three days on fluid diet. Then as soon as the diagnosis is verified, and the tongue has cleaned after the administration of saline purgatives and chlorinated quinine mixture, if the patient's temperature is not going above 103° at night, he is placed on solid food in the shape of eggs, bread and butter, and rice pudding, as well as getting his two or three pints of milk, and again, a few days later, if this diet appears to be agreeing with him, he is given fish in addition, or chicken, or butcher's meat, according to his own taste in the matter. Of course, if the case is a severe one, with a temperature keeping continuously high and a dirty tongue, with probably diarrhœa, he is kept on fluid nourishment till his fever has altered its character and the temperature come down. Stimulants are not usually required in this disease, except when there is a failing heart, when they should be given freely. In the cases, however, which are running an ordinary course, with the temperature even going high, a pint of beer or stout is often useful, given with the solid food, as tending to increase the appetite and general well-being of the patient.

Another important point in the treatment of undulant fever is to decide when a patient should be kept in bed and when allowed up. No general rule can be laid down about this, but the tendency is to keep them confined to bed much too long; in the writer's opinion, patients whose temperatures keep below 102° at night, benefit greatly by being allowed up for the greater part of the day. The great thing a patient must not do is to overtire himself in any way, as this generally means a rise in temperature the same evening, but if that is avoided, the fact of being allowed up and sitting about in the garden seems to have a great effect in cheering the patient up, increasing his appetite, strength, and weight. Each patient's case, however, must be considered separately, both with regard to his getting up and amount of solid food, as some cases with temperatures not running higher than 102° seem to be profoundly affected by the toxins of the virus, whereas others, with temperatures running much higher, seem to suffer very little inconvenience from their disease.

If the treatment described be followed, it will be found that patients seldom become anæmic, the percentage of cases with neuritis is diminished, the body weight keeps up, and the patient generally is put into a much better condition to withstand all the changes brought about by a long-continued pyrexial disease.

LITERATURE.—The literature of this fever consists for the most part of short articles by naval and military surgeons, either in the official reports of the naval and military medical departments, or published in the various medical journals, and usually dealing only with some particular point of the disease. The Italian medical journals also frequently contain the same sort of articles. The only book on the subject of which the writer is aware is *Mediterranean, Malta, or Undulant Fever,* by the late Surg.-Capt. M. L. Hughes. Macmillan Company, 1897.

Urachus.

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The segment of the allantois which is included in the body of the fœtus appears in a human embryo of the second month as a hollow fusiform body (Hertwig). In its middle part is a dilatation which becomes the bladder; the lower end is the sinus urogenitalis, whilst its upper part, a tube lined with epithelium, becomes the *urachus.* Retrograde metamorphosis is already in progress in the fœtus at term. After birth atrophy proceeds in an irregular manner. The surrounding connective tissue presses at different points against the urachus so as to cause septa to develop in its canal (Jahn). Hence the bead-like dilatations and the bilocular cysts which sometimes develop in the urachus. The urachal canal is lined with stratified epithelium, triple below, double higher up. In any unobliterated portion of the canal this epithelium steadily grows up to adult life. A valvular fold of mucous membrane covers the vesical orifice of the urachal canal and prevents escape of urine upwards from the bladder (Wutz). This *Wutz's valve* is liable to be forced open when there is any obstruction to free micturition, and sometimes yields after a urachal cyst has been excised. Traces of urachal canal remain in every individual (Suchannek). Wutz found cystic dilatations, chiefly near the lower end, in twenty-four out of seventy-four bodies.

The sheath of the canal is composed chiefly of white fibre towards the umbilicus, and of plain muscle-fibres lower down. This sheath is the "superior true ligament" of the bladder, and runs from the apex of that organ to the umbilicus. It lies between the transversalis fascia and the peritoneum, surrounded by loose connective tissue. Occasionally the urachus pushes the parietal peritoneum inwards so as to form for itself a mesentery.

Malformations.—The urachus is more or less absent in ectopia vesicæ. Garrigues, in a post-mortem on a virgin aged forty-five, who died after hysterectomy, found that the urachus was practically absent, the bladder being triangular and extending nearly to the umbilicus, to which it was connected by a very short tube. Thorn, in an operation for the removal of a pair of broad ligament cysts, noted that the bladder had a double fundus, with a double urachus joining in a cystic dilatation behind the umbilicus.

Diseases.—In two out of the twenty-four cases where Wutz discovered cystic dilatations, suppuration, due to septic inflammation elsewhere, was found in these minute cysts. Thus *inflammation* of the urachus is not unknown. It may account for some abscesses of the abdominal wall near the middle line, independent of suppuration around an old urachal fistula.

Tumours.—Bland-Sutton and Aveling report one case of myosarcoma of the sheath of the urachus, weighing nearly five pounds. Hoffmann records one case of epithelioma of the mucous membrane of the urachus in a man aged twenty-eight. The patient was born with a urachal fistula; within three years of his death it suppurated, and pus, with urine, escaped through the umbilicus.

The most important diseases of the urachus are two closely-allied conditions, *fistula* and *cyst.* Possibly some *umbilical calculi* may have developed by slow leakage of morbid secretion from an unobliterated canal. An umbilical calculus may attain the size of a pigeon's egg (Hahn). Spencer Wells, in an ovariotomy, found the urachus, though closed at both ends, open for the whole length of the abdominal incision, and filled with small urinary concretions.

Urachal Fistula; Unobliterated Urachal Canal.—The canal is often open when local malformations exist. Freund observed this condition in a woman with uterus unicornis and masculine characteristics. Pearson of San Francisco describes the case of a male child two years of age, robust and masculine, yet with no external organs; the urachus served as a urethra. Extreme distension of the fœtal bladder does not necessarily force open the urachus; thus in Couvelaire's case the urachus was found intact.

Urachal fistula, the result of patency of the canal, may be *congenital* or *acquired.*

Congenital urachal fistula is seen at birth, or develops early in childhood; under the latter circumstances it merges into the acquired variety. It may be associated with phimosis, with congenital stricture of the male urethra, and with an abnormal mucous fold closing the meatus in the female (Stierlin). But in at least fourteen cases, out of which twelve were males, no cause for the patency of the urachus could be found (Stadsfeldt). In some there were adjacent malformations, such as unusually high insertion of the ureters (Mikulicz).

Symptoms and Diagnosis.—Escape of urine from the umbilicus betrays a congenital urachal fistula. Sometimes there is a deep, funnel-shaped orifice at the umbilicus; more often the umbilical canal opens out the apex of a protuberance on the navel made up of granulations. Inversion of the bladder through the umbilicus has been recorded (Gusserow). Simultaneous catheterism through the umbilicus and the urethra will settle the diagnosis. But the urachal canal may be too narrow to admit even a probe; in such a case milk, or a solution of starch, injected into the bladder through the urethra, will most probably escape out of the umbilicus (Freer). The only other embryonic canal opening into the umbilicus is the omphalo-mesenteric duct, but a patent Meckel's diverticulum is very rare. Lexer, however, dissected out what he thought was a patent urachus in a boy aged one year and a half. On microscopical examination it proved to be a Meckel's diverticulum.

Treatment.—In every case careful search must be made for the cause of the continued patency of the urachus, then that cause, stricture of the urethra, phimosis, etc., must be treated. Spontaneous closure of the urachus often follows an operation which insures normal micturition. When no cause can be discovered, yet some complication like cystitis exists, it must first be treated, then operative measures may be advisable. In infants firm pressure from strapping has often caused permanent cure, and thus the disadvantages of an operation-scar may be avoided. Caustics, closure by hare-lip pins, or even resection of the canal alone, are known to be unsatisfactory. The umbilicus must be dissected off by a circular incision, then the urachus is set free, and a small piece of the bladder around its inferior attachment is excised by a transverse incision. The wound is at once closed by suture. During the operation a catheter must be held in the bladder, and any wound of the peritoneum closed at once with fine silk. It is best to drain the lower angle of the abdominal wound with a strip of gauze. Unless the small piece of bladder which includes Wutz's valve is removed that valve may be forced, and a fistula will develop in the stump of the urachus. A ligature is apt to cut through the stump without obliterating the canal. This operation has given very good results (Delagenière, Lexer, Mikulicz). The abdominal wound must be carefully closed with sutures.

Acquired urachal fistula signifies the forcing open of an imperfectly closed urachus in adult life or late in childhood. Wutz's valve is forced by pressure of urine, which enters the urachal canal and opens up its umbilical orifice. Among the causes of this form of fistula are stricture of the urethra, enlarged prostate, chronic cystitis, pressure of an ovarian cyst on the bladder (Cinti), and retention of urine from retroversion of a gravid uterus (Unterberger, Neugebauer, Drummond Robinson, and probably Chopart's case). In Levêque's case, where a man aged eighty had passed urine through the umbilicus ever since he was fifty-five, there was neither stricture nor any other apparent cause for the fistula. Vesical calculi may be associated with the fistula (Goldschmidt). In Paget of Leicester's case the calculus was ring-shaped, and had developed on a hair. It was extracted through the umbilicus.

Acquired urachal fistula is a serious condition, for it nearly always implies disease of the lower urinary tract, and not rarely "surgical kidneys" as well. There is often much low inflammation around the fistula, which then forms a sausage-shaped swelling (von Bramann).

Diagnosis of acquired fistula is easy when simultaneous catheterism through the urethra and the umbilicus is practicable, or when a probe can be passed into the bladder from the umbilical orifice. But catheterism is not always possible. Freer's starch solution (see above under "Congenital fistula") should be tried. Gall-stones and echinococci have been known to escape through the umbilicus, and discharge of pus and serum often precedes their exit. Umbilical calculi made up of cotton and woollen fibres felted together with sebaceous matter may also set up free discharge. In all these conditions the discharge must not be taken for urine mixed with pus. But gall-stones have been found in the urachal canal (Bramann), and in Faber-Köstlin's case, where fifteen gall-stones had been discharged through the urethra in three years, it was discovered after death that the urinary and gall-bladders communicated through an open urachus. It is doubtful whether a diverticulum of the bladder can push its way to the umbilicus. Alleged cases may have been instances of urachal fistula or of bladder replacing the urachus (seen Garrigues' case, above). Some authorities believe that extravasated urine may leak along the connective tissue of the urachus and find its way out of the umbilicus. A patent Meckel's diverticulum is to be distinguished by examination of a piece of its mucous membrane (see Lexer's case, above). Instead of the stratified epithelium of the urachus most of the structures of intestinal mucosa will be detected.

Treatment.—The fact already noted that acquired urachal fistula is often associated with disease of the urinary tract must never be overlooked. Neglect of this principle means the certain failure, if not worse, of any radical operation. If, on the other hand, the state of the bladder, etc., is considered and treated, spontaneous closure of the fistula may follow. This occurred in Fraser's case, treated by free washing out of the bladder and urachus, and in Goldschmidt's (see above) after suprapubic lithotomy, but not in Paget's case, for urine continued to escape through the umbilicus six years after the stone had been extracted from the fistula. Exposure of the urachal canal and scraping its mucosa are dangerous and caustics unsatisfactory. When the urinary tract and the tissues around the urachus are healthy, complete resection of the fistula, as described above under the treatment of congenital fistula, has proved permanently successful.

Urachal cyst includes two varieties: cystic fistula and true cyst. The first is *cystic dilatation* of the urachal canal which opens into the bladder, but is closed at the umbilicus. G. Morgan's (Brighton) was in a boy, aged five. Newman's patient was a man aged thirty-nine, and subject to a hypogastric swelling. Pain and retention of urine set in suddenly without apparent cause. Twenty ounces of bloody urine were drawn off from the bladder; a cyst was then detected above it. A fortnight later an operation was performed, the cyst was entirely in front of the peritoneum. It was drained, urine escaped from its cavity for about a month, then it closed completely.

The second variety is *true cyst of the urachus,* about which much has been written. But the term "urachal cyst" has been applied by Hoffmann and Lawson Tait to cases where there was little or no evidence that the tumour had developed from the urachus. Wutz has noted that in Hoffmann's often-quoted case, where fifty litres of fluid were found in the cyst, the urachus was quite distinct. Lawson Tait failed to prove that any of his big so-called "allantoic cysts" were urachal. Some were clearly intraperitoneal (see author). Tait's theory that the allantois may form a kind of serous membrane for the pelvic viscera has never been proved by dissection.

An unobliterated portion of the urachal canal is often detected at an abdominal operation. This condition represents the origin of true cysts of the urachus of which several authentic cases have been reported. They are not associated with malformation of the rest of the genito-urinary tract, excepting one of Bryant's cases, where there was hypospadias. In any case it is possible that Wutz's valve may be forced after the cyst has developed so that it is not always easy to distinguish true cyst from cystic fistula.

In the author's case the cyst was bilocular. The larger and upper cavity contained over a pint, the smaller about half a pint of a greenish brown fluid. In one case under Bryant ovarian cyst was suspected. The tumour, preperitoneal as in all urachal cysts, was closely associated with the fundus of the bladder. In a second case under that surgeon a painful swelling developed below the umbilicus in a man aged thirty-five, with slight hypospadias. During drainage after incision some urine came away. Ill, of Newark, New Jersey, reports a bad case of urinary fistula after draining of a closed or true cyst. Ferguson, of Troy, N.Y., operated on a man aged forty-seven. The cyst contained two quarts of a watery fluid, and bore a distinct and separable lining membrane which sent digital prolongations between the layers of the abdominal wall near the navel, as often seen in umbilical hernia. Douglas of Nashville removed a urachal cyst containing twenty-five pints of fluid. Lawson Tait enucleated a hypogastric preperitoneal cyst which dipped into the pelvis; the patient was a woman aged twenty-eight. In Rotter's case the cyst-walls were continuous with the coats of the bladder, and at the point of junction was a villous cancer of the vesical mucous membrane already detected by the cystoscope. The cancer and the bladder-walls around it were dissected away together with the urachal cyst. Ill incised and drained a hypogastric cyst of ten years' duration during the third month of pregnancy; over eight pints of fluid came away. In Morestin's case two distinct cysts, developed from the bead-like dilatations mentioned at the beginning of this article, were detected during an operation for pyosalpinx.

Diagnosis.—Urachal cyst forms a fluctuating swelling between the umbilicus and pubes. When it varies in size in the course of a few months its nature will be more clear, as it probably communicates with the bladder. The true cyst is entirely separate from the bladder, it tends to increase slowly, and does not become smaller when the bladder is emptied by the catheter. Its anterior surface is often flat, as it meets resistance from the sheaths of the recti, and so bulges backwards towards the peritoneum rather than forwards. In position it is not always symmetrical, sometimes it lies mainly on one side of the middle line. As a rule, it is only by an exploratory incision that the nature of this kind of cyst can be made evident. Then it will be found that the parietal peritoneum lies entirely behind it. In the female a preperitoneal cyst may arise from the broad ligament, burrowing forwards and upwards (Wutz or Wolff's case; author), but the base of such a tumour lies in the iliac fossa, not over or behind the bladder. The walls of a urachal cyst may show plain muscular fibre under the microscope (author's case); the urachal epithelium is usually destroyed. Encysted dropsy has been taken for a urachal cyst.

Treatment.—When the cyst, owing to chronic inflammatory changes, cannot be enucleated, it must be drained. This treatment answers well in bad cases, but urinary fistula may develop. In Bryant's second case, in Ill's, and in the author's, drainage was followed by closure of the cyst. When the cyst walls are healthy enucleation should be attempted. Tait, Bryant (case 1), and Rotter successfully enucleated the cyst, and had no trouble with the parietal peritoneum. Douglas lost his case of enucleation through sloughing of the large peritoneal flap detached from the back of the cyst. In Ferguson's case the inner wall of the cyst was stripped off almost entirely. Much of the outer wall with the underlying peritoneum was excised, and puckering of the remainder of the wall remedied by suitable application of sutures. The danger of urinary fistula through forcing of Wutz's valve must be remembered, as in operations for urachal fistula. Ill found a short tract of patulous urachus between a urachal cyst and the bladder. He treated this tract as though it were a diseased vermiform appendix, cutting it very short, forcing in the cut edges, and closing them in with a Lembert suture. Excision of a small piece of the walls of the bladder around the inferior attachment of the cyst, as in the operation for fistula, might be still safer surgery in such a case. It should always be practised, if possible, in operations on cysts of the first variety, mentioned above, where the bladder communicates with the cyst cavity from the first.

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Uræmia.

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Uræmia.—Uræmia is a convenient comprehensive term for numerous toxic symptoms met with in the course of several forms of renal disease, or in connection with interference with the ordinary eliminative work of the kidneys. The symptoms are, in the main, due to toxic functional disorders of the nervous system, and accordingly are generally of a nervous type, but occasionally they simulate diseases of the respiratory and digestive systems.

Uræmic symptoms may be divided into three broad clinical types:—

1. Acute or fulminating.
2. Chronic, subacute, gastro-intestinal, or respiratory.
3. Latent.

1. Acute or Fulminating Uræmia.—This type occurs mainly with acute nephritis, especially when resulting from scarlet fever; it may arise in chronic nephritis, when the urine is reduced in amount, in consequence of a subacute extension of the disease. It often accompanies non-obstructive suppression of urine due to catheterism, abdominal injuries or diseases, or operations upon the kidneys. Severe renal congestion, the result of disease, or of poisons or toxins developed in the course of disease, is also frequently followed by acute uræmia.

The onset may occur without any warning, or it may be preceded by various premonitory symptoms.

Premonitory Symptoms.—The most marked premonitory symptoms are constant headache, mental apathy, drowsiness, and vertigo; nausea, or even vomiting, may sometimes occur, while in some few cases there may be severe dyspnœa. Occasionally there is marked diminution in the quantity of urine. Attention has been directed to a strange, fixed expression of the face, to dragging pains in the extremities, or to a transient rigidity of the face, of the lower jaw, or of one of the limbs. Tremors, similar to those of paralysis agitans, have also been described. Abnormal hardness and high tension of the pulse commonly precede the more obvious symptoms of uræmia.

SYMPTOMS.—(i.) *Convulsive Attacks.*—The symptoms fall into two classes: Those due to paralytic affection of the brain and of some of the sensory centres, and those referable to irritation of the motor tract, leading to tonic and clonic convulsions. Frequently both types are present in varying degree. The immediate onset is often marked by sudden paroxysms of convulsions of an epileptiform type, which may occur with or without premonitory symptoms. The patient becomes unconscious and convulsed; sensibility and reflex actions are lessened and frequently abolished. In slight cases the spasms may be confined to passing contractions of the muscles of the face or of the extremities, but in serious cases they may be more violent and general, and the whole body may be shaken with violent convulsions, while respiration falters and becomes stertorous. In such severe cases the patients foam at the mouth and grind their teeth, while fæces and urine may be passed involuntarily.

The clonic spasms ordinarily only last a few minutes. When but one fit occurs the convulsions cease gradually, and the patient passes into a drowsy or comatose condition, from which he may be partially roused for a short time, and again appears to fall asleep. After an interval, varying from a quarter of an hour to several hours, he awakes as from profound sleep. Generally, after a few hours or days, the attacks return with renewed vigour, the intervening stupor becomes more profound, and at last passes on to permanent coma. Death may occur during the comatose state, or at the height of one of the convulsive seizures.

The clonic convulsions are sometimes unilateral, and may be preceded or replaced by tonic spasms, constituting "tetanic uræmia," which may be of long duration.

Occasionally there are no spasms, the acute uræmia being marked by vomiting and an apathetic condition, which gradually passes on to coma or delirium. In a fatal case without convulsions recently observed aphasia and marked contraction of the pupils were the chief signs preceding coma.

A convulsive attack is sometimes accompanied or followed by some form of motor paralysis, especially hemiplegia; this is frequently transient and incomplete, but reflexes are abolished or diminished, and the condition may be followed by contracture. When the face is affected ptosis is exceptional, but conjugate deviation of the eyes has been observed.

(ii.) *Temperature.*—During the convulsive attacks the temperature is generally low, or even subnormal, but in exceptional cases great rises of temperature have been noted. Low temperatures, ranging from 86·1° Fahr. to 94·4° Fahr. have been noted in uræmia consecutive to diseases of the urinary passages; it has been suggested that low temperatures are more frequent when uræmia affects persons advanced in years, or when it occurs in conjunction with exhausting conditions, such as vomiting, diarrhœa, or hæmorrhages, or in connection with cancerous cachexia.

In the rare cases in which the temperature has been found to rise as high as 105·8°, or even 107·4°, this sudden elevation has always been followed by a rapid fall.

(iii.) *The Pupils.*—During the convulsion and subsequent coma the pupils usually retain their sensitiveness to light, but authorities are not agreed about their size. Fagge says they are more often contracted or normal, while Wagner states that they are as a rule dilated, seldom small; in my experience I have found no definite change with sufficient frequency to warrant a general statement.

(iv.) *Special Senses, Sight and Hearing.*—Convulsions may be followed by dimness of vision or even by actual blindness, which may be transient or permanent. The condition has been attributed to transient œdema of the retina, or to œdema of the brain. Ophthalmoscopic examination during uræmic amaurosis generally gives negative results, and the pupillary reflex is intact. Vision may be regained after twenty-four or thirty-six hours, and recovery has been known to occur even after seventeen days of total blindness.

The sense of hearing is comparatively rarely affected, but occasionally it is impaired as the result of uræmia. Singing in the ears, difficulty in hearing, or complete deafness may suddenly supervene and depart as quickly. Uræmic deafness has been attributed to minute hæmorrhages in the cochlea, but, from the rapidity of recovery, it is far more probable that it generally depends upon some toxic influence acting upon the auditory centre.

2. Chronic Uræmia.—The most obvious symptoms of chronic uræmia are those connected with the respiratory and digestive systems, but several distinctly cerebral symptoms are to be noted, and there are good grounds for believing that, in all cases, the toxic influence is mainly, if not entirely, exerted upon the central nervous system.

Symptoms.—(i.) *Nervous.*—The onset is often very gradual, and may be unrecognised or attributed to some other cause. Frequently there is complaint of dull headache affecting the occipital region, or less commonly the frontal; occasionally the pain is more acute and, when paroxysmal, it simulates violent migraine. It may be accompanied or replaced by giddiness and drowsiness, or by languor and inertia, which gravely interfere with all mental and muscular efforts. These symptoms are peculiarly persistent, though there may be brief intermissions. They may be succeeded by respiratory and digestive symptoms, or the lethargy may increase until it leads to stupor or coma, with perhaps attacks of delirium or with convulsive seizures similar to those of acute uræmia. When coma supervenes without convulsions the tongue becomes dry and brown, sordes collect upon the teeth, and the condition resembles that of an advanced stage of typhoid fever.

The mental derangements in chronic uræmia include hallucinations, terror, delusions of persecution, and excessive motor irritability. The type of delirium is generally quiet, but occasionally it may be furious. Binswanger, who describes several cases, has found that exacerbations and remissions of the renal disease keep pace with similar variations of the symptoms of mental derangement.

Severe itching of the skin is very frequent and often very distressing. In old people it leads to intense pruritus which defies all local treatment. The irritation may disturb sleep, and even when sufficiently comatose to resist all efforts at rousing them the patients may continue to rub and scratch themselves. Cutaneous hyperæsthesia with burning or stabbing sensations are sometimes met with.

It is possible that some of the eruptions which occur in uræmia are primarily due to central nervous changes; they may appear as maculæ or papulæ of a bright red colour upon the extensor surfaces of the forearms and legs, spreading rapidly over the whole body, or as an erythematous, scarlatiniform, papular, or vesicular eruption. Sometimes the rash becomes eczematous; frequently it is accompanied by severe itching.

(ii.) *Respiratory System.*—Reference has already been made (see article on "NEPHRITIS," vol. viii.) to the various forms of dyspnœa met with in uræmia independently of the dyspnœa due to œdema of the lung or fluid in the pleural cavity, though frequently associated with these conditions. The chief types are (1) continuous dyspnœa; (2) paroxysmal dyspnœa; (3) Cheyne-Stokes breathing. The symptoms of (1) and (2) resemble those of spasmodic asthma in their sudden onset, and they are frequently accompanied by sibilant râles, but the term "uræmic asthma" is to be deprecated. The condition does not ordinarily yield to any of the usual remedies for asthma, while relief may sometimes be afforded by measures calculated to remove nitrogenous waste material. The attacks usually occur at night, and the dyspnœa is often mainly expiratory, though there may be much inspiratory difficulty. The dyspnœa has often a peculiar hissing character, suggestive of laryngeal trouble, but it is undoubtedly due to central changes, rather than to laryngeal or pulmonary obstruction. Similar breathing may occur in connection with acute uræmia, indeed it is considered to be most common with the uræmia of scarlatinal nephritis; in chronic cases it is thought to be most frequent when the nephritis results from alcoholism. It must be remembered that attacks of dyspnœa in chronic nephritis may be due to gradual failure of the circulation, or to interference with the work of the lung, owing to engorgement or to effusion into the pleural cavity, and that these conditions are not necessarily associated with uræmia.

The well-known Cheyne-Stokes respiration frequently occurs shortly before death in cases of chronic nephritis, especially in those with secondary cardiac failure, and it is generally thought to be of toxic origin.

Persistent hiccough is another distressing symptom in severe cases tending to a fatal termination. It has been observed in numerous cases of renal cirrhosis and extravasation of urine. Although hiccough is generally regarded as a late symptom, it has occasionally been noted early, when only slight œdema of the legs was present.

(iii.) *Digestive System.*—Dyspeptic symptoms are common throughout the course of chronic forms of kidney disease. In the earlier stages of renal cirrhosis they may be of an ordinary type, but when the renal changes are more advanced nausea and vomiting become more frequent, and in their intractable character they resemble other forms of chronic uræmia. The vomiting cannot be traced to any error of diet, and it affords no relief. It often occurs in the early morning, before food has been taken, and the vomited matter may consist either of acid fluid or of alkaline fluid with an ammoniacal odour. Urea has been detected in this fluid, and the alkaline reaction has been attributed to its transformation into ammonium carbonate. It has been suggested that the vomiting is the result of irritation of the stomach by urea or ammonium carbonate, which are being vicariously eliminated. Probably this is erroneous, and the vomiting is of central origin, since when urea has been administered to animals with food, vomiting only ensues after an interval sufficient to allow of absorption.

Diarrhœa is generally a late symptom, and it may be overlooked or rather attributed to the treatment unless it is associated with uræmic vomiting. Diarrhœa is stated to be most troublesome during the night, when six or more watery stools may be passed, though during the day there may have been only one or two actions of the bowels. This feature is of some diagnostic importance, since in advanced nephritis dysenteric symptoms with definite lesions are not uncommon.

3. LATENT URÆMIA.—Under this term a third variety has been described, in which all the most obvious symptoms of uræmia are conspicuous by their absence. This form is common with calculous anuria and other varieties of obstructive suppression. In these conditions death occurs in from five to nine days, and the leading symptoms are contracted pupils, a low temperature, occasional vomiting, and towards the end slight muscular twitchings and slight drowsiness. The negative characteristics are the absence of coma, convulsions, and dyspnœa, consciousness being retained until very shortly before the end.

THEORIES OF URÆMIA.—Although from the clinical side it may be convenient to include under a comprehensive term diverse symptoms which are undoubtedly the result of kidney disease, it must be remembered that the term *Uræmia* is somewhat misleading unless it is employed in a very wide sense.

Numerous theories, explanatory of the symptoms, have been suggested, and arguments can be adduced in support of most of them. Many turn upon some interference with the eliminative work of the kidney, whereby the system becomes surcharged with one or more of the urinary constituents, which may be directly toxic, or may exert a toxic influence after undergoing some chemical change in the body. The attempt to find a single theory which shall afford a satisfactory explanation of all cases seems doomed to failure in view of the complexity of the symptoms of uræmia.

The theories of uræmia may be broadly divided into two classes:—

1. Mechanical.
2. Chemical.

According to the first some definite physical change affects the nerve centres, such as œdema or minute hæmorrhages; according to the second, the symptoms are to be explained on the theory of the toxic influence produced by some retained constituent of the urine, or resulting from the action of some material formed by decomposition or metabolism within the system.

1. *Mechanical.*—Numerous minute hæmorrhages have been found in various parts of the brain, but these are so rare and so uncertain that they must be regarded as the results rather than the cause of the convulsive seizures. Traube thinks that the basis of uræmic symptoms is to be found in œdema of the brain, which from its increased volume induces anæmia. Two conditions predispose to œdema—the marked hydræmia and the increased arterial pressure. If the arterial tension is by some accidental means suddenly raised, or the density of the blood serum suddenly further diminished, the serous fluid will transude into the brain substance and cause œdema. Traube considers that the special symptoms of the uræmic attack are dependent upon the degree and localisation of the œdema in the brain: convulsions occur when the middle lobes are affected; coma when the œdema extends to the whole cerebrum. Traube's theory is supported by (1) the frequency of cardiac hypertrophy and hydræmia in cases of uræmia; and (2) by the production of coma and convulsions in dogs by the injection of water into the carotid after ligature of the ureter and of one of the jugular veins. Against this theory it has been urged that the symptoms are only produced experimentally when enormous quantities of water have been injected, and that even under such circumstances the brain may present no indication of œdema. Moreover, from the clinical side hypertrophy of the heart and hydræmia are not always accompaniments of uræmia, while post-mortem examination frequently fails to demonstrate œdema of the brain. Even when cerebral œdema has been recognised it has been thought to be the result of the convulsions rather than the cause. In spite of these objections Traube's theory has, in a modified form, found several adherents; it has been held that in scarlet fever inflammatory œdematous conditions of the brain and its meninges co-operate with the action of some result of infection.

2. *Chemical.*—The term "uræmia" was first employed under the idea that all the symptoms depended upon the non-elimination of urea, its circulation in the blood, and its toxic action upon the central nervous system or upon other organs.

The following observations have been advanced in favour of the theory that uræmia is due to the *retention of urea* :—(i.) The appearance of marked symptoms when the secretion of urine and the elimination of urea are much reduced ; (ii.) the detection of urea in the blood under these conditions ; (iii.) the production of many of the ordinary symptoms, such as drowsiness, convulsions, and vomiting, when the excretion has been experimentally arrested by ligature of the renal arteries, or the ureters, or by extirpation of the kidney.

Against the retention theory it must be admitted (i.) that all symptoms of acute uræmia may be absent when complete suppression has lasted for many hours, or even days, without being accompanied by vomiting or diarrhœa, through which vicarious elimination might have been effected ; (ii.) that uræmic symptoms, in their frequency and severity, do not clinically exhibit any necessary relation to the quantity of urea excreted ; (iii.) that occasionally no symptoms of uræmia may be present, even though large quantities of urea may be detected in the blood ; (iv.) that when urea is given to animals with their food no symptoms are produced so long as it can be freely excreted; (v.) that frequently in dogs uræmic symptoms are not produced even by the injection of large quantities of urea into the circulation. By the extirpation of the kidneys it has been possible to estimate the amount of urea retained within the system from the time of the operation until the time of death from uræmic symptoms, and it has been found that far larger quantities may sometimes be introduced directly into the blood without any resulting uræmia.

Some observers maintain that if in animals the rapid elimination of urea is prevented by ligature of the ureters, death with uræmic symptoms occurs much more quickly than where the kidneys have been extirpated : this appears to indicate that the presence of urea is not the sole determinating factor in uræmia, but that in all probability some other deleterious substance is elaborated by the kidney.

As the result of much experimental work Frerichs suggested that the toxic agent in uræmia might be *ammonium carbonate*, resulting from the decomposition of urea in the blood, owing to the presence of some ferment. The arguments in support of this theory are (i.) the comparative ease with which urea can be transformed into ammonium carbonate ; (ii.) the ammoniacal odour of the breath in cases of uræmia ; (iii.) the occasional detection of small quantities of ammonium carbonate in the blood in puerperal eclampsia ; (iv.) the similarity of the symptoms produced by the experimental injection of ammonium carbonate ; (v.) the possible absorption of ammonium carbonate resulting from decomposition of urea within the intestine or urinary passages. The objections to this theory are (i.) that the ammoniacal odour of the breath depends upon decomposition within the mouth ; (ii.) that it occurs both in health and in sickness, and is not limited to renal affections ; (iii.) that in uræmic persons this transformation of urea in the blood does not occur ; (iv.) that the injection of urine, which has undergone spontaneous decomposition, is not followed by uræmic symptoms unless the urine has been made septic by infection.

The difficulties connected with the two chemical theories above mentioned led Feltz and Ritter to test the effects produced by the intravenous injection of the various constituents of the urine. They concluded that the convulsions, coma, and death which ensued after the injection of fresh urine could not be attributed to increased pressure, nor to the organic constituents, and that the *potassium salts* were the most powerfully toxic of the inorganic constituents. They maintain that similar symptoms of uræmia were produced by injecting either fresh urine or distilled water containing the same proportion of salts of potassium. By one observer symptoms of respiratory trouble have been attributed to the retention of salts of potassium ; while another considers potassium chlorate to be the principal cause of vomiting. In opposition to this theory of the toxic influence of potassium salts, it has been stated that in some cases of puerperal eclampsia the proportion found in the blood was below the normal amount ; it must be remembered, however, that many of the clinical features of eclampsia differ from those of uræmia.

Alteration in the excretion of *chlorides* has been suggested as an explanation of uræmia. Clinically marked diminution of chlorides in the urine has been noted in acute and chronic nephritis, and the hypodermic injection of a concentrated solution of sodium chloride has been followed by chronic and tonic spasms alternating with a semi-comatose condition.

Symptoms resembling those of uræmia have been produced by irritation of the cortex cerebri by creatin, creatinin, leucin, and tyrosin, and the late Sir William Roberts regarded uræmia as the result of the accumulation of these or similar substances in the blood, that is to say, of products intermediate between urea (or uric acid) and the albuminous substances from which it originates.

Bouchard has propounded an extremely interesting theory of auto-intoxication according to which the human body manufactures poisons, which are only prevented from destroying life by their rapid elimination. The kidneys excrete toxic substances such as urea, potassium carbonate, etc., while the intestine removes compounds of potassium and ammonium. If these substances are retained in the body they are said to produce symptoms of uræmia as soon as the "uro-toxic coefficient" is attained.

Recent examination of the blood and tissues in renal diseases has given the following results: (1) In suppression there is a great increase in the nitrogenous extractives in the blood and tissues; (2) in acute uræmia without dropsy there may be a still greater increase; (3) in chronic renal disease fatal from other causes there is some increase, but not comparable with the above; (4) in renal disease, even in apparent good health, there is a certain small excess; and (5) in eclampsia the excess is trivial in amount. From these and other data Bradford maintains that uræmia cannot be held to be due to simple retention, and that in kidney disease, and after experimental lesions of the kidney, there is evidence of great tissue disintegration, and that it is more than probable that uræmia is dependent upon this, directly or indirectly. He suggests that the kidneys in some way control the metabolism of the tissues of the body, and that, when the kidney substance was greatly diminished in amount or entirely removed, the blood not only contained a great excess of urea, but the tissues, and especially the muscles, contained large quantities of urea and other nitrogenous bodies of the creatin class. Several other observers have also noted that in uræmia there is an accumulation of creatin-like bodies.

The frequent occurrence of uræmic symptoms during the rapid disappearance of renal dropsy is extremely suggestive. It has been thought that certain toxic alkaloids or ptomaines become stored up in the dropsical fluid, and that they may under certain conditions, especially when attempts are made to reduce the dropsy rapidly, be suddenly thrown into the circulation, and thus induce convulsions and coma. Such symptoms are usually attributed to reabsorption of nitrogenous materials, but Dr. William Carter has suggested that they may be due to a progressively diminished alkalinity, or perhaps actual acidity of the blood. In support of this contention he states that although, under ordinary circumstances, subcutaneous effusions are alkaline or neutral, in Bright's disease they are frequently acid.

From the clinical side it appears almost impossible to accept any single chemical theory in explanation of all forms of uræmia. It has been argued that poisons like morphine, arsenic, or belladonna, produce very different symptoms in different individuals, or in different doses, and that therefore there is no inherent difficulty in assuming similar variations as the result of a single poisonous substance in uræmia. Although this argument is perhaps permissible with the ordinary symptoms of acute and of chronic uræmia, it is scarcely to be regarded as satisfactory when applied to the modified forms of either condition. It is more likely that these variations are due to the accumulation within the body of several poisonous products of slightly different action, than that they can be ascribed merely to idiosyncrasies or to different doses of one toxic substance.

DIAGNOSIS.—When the previous medical history is known there is usually little difficulty in correctly estimating the symptoms of the acute form of uræmia. Changes in the urine, both in volume and in specific gravity, may have sounded a warning note, or attention may have been attracted by various premonitory symptoms, and the uræmic manifestations may have been anticipated. The chief difficulty arises in patients found convulsed, or comatose, and brought under medical notice without any definite history. Suspicion may be aroused by an ammoniacal odour of the breath, though this sign is frequently masked by the smell of alcohol, taken previous to the attack or administered with good intent by some bystander. The presence of dropsy, even slight in amount, would be a valuable indication, while high tension of the pulse, outward displacement of the apex beat, and accentuation or reduplication of the sounds of the heart, would favour the diagnosis of uræmia in a convulsed or comatose patient. If urine withdrawn by a catheter is found to be albuminous and to contain casts, the hypothesis of uræmia is further strengthened. Many of these indications may, however, be present with grave cerebral lesions, with which renal changes may be directly associated. Cerebral hæmorrhage, for example, often results from arterio-sclerosis, a sequel of renal cirrhosis, and when the sudden unconsciousness is accompanied by convulsions the diagnosis may be very difficult. Although uræmic convulsions may be unilateral, or at least more marked upon one side, as in hemiplegia, the recognition of distinct paralytic symptoms generally points to hæmorrhage rather than to uræmia. Convulsions and coma may also be due to various forms of cerebral tumour, or of meningitis, particularly tuberculous, which may occur independently in patients already affected by chronic renal trouble. Alterations of temperature afford very little help to the diagnosis; in meningitis the chart is not characteristic, in apoplexy the temperature may be normal or subnormal, though usually high in basal hæmorrhage, while in uræmia the occurrence of a high temperature is quite exceptional. Help may be afforded by an ophthalmoscopic examination, which may disclose characteristic white patches or flame-shaped hæmorrhages when acute uræmia occurs with chronic renal changes, while in many cases of meningitis and of cerebral tumour optic neuritis and other equally marked deviations from the normal may be recognised.

The convulsive seizures of uræmia may at first be mistaken for hysteria or epilepsy, but an examination of the urine and the recognition of injury of the tongue should leave no room for doubt.

The coma of uræmia may be mistaken for that due to alcohol, to opium, or to diabetes. With alcoholic coma the pupils are generally dilated, while they are contracted in opium poisoning. In diabetes the pupils afford no help, and the examination with the ophthalmoscope may reveal changes very similar to those in chronic nephritis. The examination of the urine, of the pulse, and of the heart may serve to indicate the true cause. Reference has already been made to the difficulty of dealing with the cases of prolonged partial coma, with dry, furred tongue, in which there is marked resemblance to the late symptoms of typhoid fever.

The diagnosis of chronic uræmia may give even greater trouble than that of acute, and may only be reached when symptomatic treatment has proved unavailing. The nervous symptoms—headache, neuralgia, and languor—are characterised by being peculiarly persistent and intractable; they differ from similar conditions of rheumatic origin in presenting but little change with climatic alterations; small traces of albumin and low specific gravity may aid the diagnosis, but the position of the apex beat, the sounds of the heart, especially the accentuation or reduplication over the pulmonary valves, and alterations in the pulse, increase of tension, or the characteristic sphygmographic tracing, are to be regarded as of greater value.

In advanced cases of chronic nephritis, shortness of breath on exertion, tendency to recurrent cough, and occasional attacks of spasmodic dyspnœa, can only be attributed to uræmia, in the absence of physical signs of cardiac or pulmonary affections, or when the symptoms persist in spite of improvement in the physical signs. Usually symptomatic treatment is first adopted, although a provisional diagnosis of uræmia may have been made, and it is only when the ordinary remedies fail to give relief that increasing confidence is felt in the theory of toxæmia, and a change of treatment may give surprising benefit.

Similarly, dyspeptic symptoms, vomiting, and diarrhœa may be mistaken for the results of local lesions of the stomach or intestines; the absence of physical signs of tumours connected with the stomach, the sigmoid flexure, or the rectum, helps to differentiate uræmia from malignant diseases of these organs, and greater certainty may be attained by the examination of the vomited materials, or by testing for free hydrochloric acid after the removal of the contents of the stomach. The wasting, pallor, and weakness of advanced nephritis resemble those resulting from malignant growths. It must be admitted, however, that in chronic uræmia the symptoms so frequently resemble those due to other causes, that, in spite of the utmost care, it may be advisable to await the results of treatment before expressing a definite opinion as to the nature of the case.

Prognosis.—The prognosis of uræmia is always serious. The immediate danger depends upon the type of uræmia, and also upon the form of renal disease. Symptoms of acute uræmia necessarily cause great anxiety; death may ensue in the course of the first convulsive attack, but it more commonly results from exhaustion, when numerous attacks are repeated at short intervals. In scarlatinal nephritis the prognosis is somewhat more hopeful than in the more ordinary form of acute nephritis; in both conditions the prognosis is influenced by the rapidity with which the coma passes off, and by the speedy re-establishment of the renal excretion. When convulsions occur with chronic nephritis they may similarly prove fatal during the first attack, and although in exceptional cases the end may be remote, it usually occurs within a few weeks or perhaps months. In such cases the prognosis will be based upon the degree of stupor or coma after the convulsive seizures, and upon the general characters of the urine.

Respiratory and digestive disturbances, indicative of chronic uræmia, always justify an unfavourable prognosis. The immediate dangers of uræmic dyspnœa are sufficiently obvious, while vomiting and diarrhœa, even when not direct preludes to convulsions or coma, reduce the strength greatly and thus increase the risks. Giddiness, headache, neuralgia, and even amaurosis indicate progressive stages of uræmia; but, unless accompanied by a rapid diminution in the specific gravity or in the amount of the urine, they may improve greatly with treatment, or they may remain with little variation for months or even years.

Treatment.—In the article on nephritis will be found a full account of the measures ordinarily adopted to prevent the occurrence of threatened uræmia; it may, however, be useful to give a brief summary here, and to mention the special treatment which may be employed for individual symptoms.

Threatened uræmia entails the use of diaphoretic measures or drugs, of hydragogue purgatives, and occasionally of diuretics. Free diaphoresis is favoured by hot-air baths, hot-water baths, and by the wet pack, hot or cold; the action of these may be promoted by copious draughts of water, taken, for instance, while having a Turkish bath. In very exceptional cases when these diaphoretic measures fail, or when they increase headache, a very small dose of pilocarpine may be injected subcutaneously to initiate diaphoresis. This drug should, however, only be employed on great emergency, and it should never be used when the patient has pulmonary œdema, and is already unconscious.

Diaphoretic drugs are seldom employed in the early stages of uræmia, as many exert a stimulating action upon the renal vessels which is undesirable. Ammonium acetate has fallen into disfavour since the suggestion that uræmia might be due to ammonium compounds in the circulation.

Of the hydragogue purgatives jalap and scammony are the most useful; the official compound jalap powder is frequently administered. Elaterin is sometimes recommended; croton oil is ordinarily reserved for patients already comatose. Calomel should be avoided when the urine contains blood, though in other cases it may be of service.

The convulsions of acute uræmia may be controlled by the administration of chloroform; chloral hydrate and potassium bromide have been given with the same object. When in spite of these measures convulsions occur in rapid succession, the subcutaneous injection of morphine has been advised. This treatment is generally thought to be extremely hazardous; many observers maintain that it increases the tendency to fatal coma. In plethoric individuals, when diaphoretic measures and hydragogue purgatives fail to check convulsions, venesection is often of service; the removal of twenty ounces of blood, or more, may give great relief. Even with great weakness or threatening collapse, venesection may still be performed with advantage if, at the same time, an intravenous injection of normal saline solution is employed.

With coma, diaphoresis and catharsis should be continued, or chloral hydrate and potassium bromide may be given. The inhalation of oxygen has been tried, with indifferent success, to check the hissing dyspnœa.

The spasmodic dyspnœa of chronic uræmia is sometimes benefited by the administration of nitroglycerin (trinitrin) in solution, or by the inhalation of amyl-nitrite; preparations of ether and other diffusible stimulants are also of service. Frequently, however, it will be found that the dyspnœa yields more rapidly when the hot-air baths are employed in conjunction with hydragogue purgatives.

Similarly, although neuralgia and headache may sometimes be relieved by phenacetin or acetanilide, better results ordinarily accompany an eliminative line of treatment.

Nausea and vomiting may be controlled by ice, by diluted hydrocyanic acid, and by preparations of bismuth, but the due recognition of their uræmic character and the adoption of diaphoretic and purgative measures will often give greater relief.

Ureters. *See* KIDNEY.

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INTRODUCTION.—The urethra or duct of the bladder differs both anatomically and physiologically in the male and female. It is more complex in the male, because it is the seminal channel, whilst in the female its only function is to discharge urine. The male urethra, therefore, is subject to a much greater number of pathological conditions than that of the female.

ANATOMY.—*The Male Urethra* measures 8 to 9 inches in length, and extends from the neck of the bladder to the urinary meatus. It is a continuous tube of mucous membrane, which is divided for descriptive purposes into the prostatic, membranous, and spongy or bulbous portions, but for the practical purposes of treatment into anterior and posterior parts, the anterior portion lying in front of the compressor urethræ, the posterior within and behind this muscle. The anterior urethra, therefore, extends from the meatus to the anterior layer of the triangular ligament, whilst the posterior urethra includes the membranous and prostatic portions. In a normal adult the posterior urethra begins at a point over 5 inches and under 7 inches from the meatus, for it is at this depth that an instrument is grasped by the compressor urethræ when it is being passed along the urethra. The urethra is a potential tube, for its walls are nearly in apposition, except during the passage of urine and semen. Its mucous membrane exhibits a number of pouches—the lacunæ of Morgagni—which are more numerous in the upper than in the lower wall; they are lined with cylindrical epithelium, and their orifices are directed towards the meatus. A blind pouch protected by a fold of mucous membrane—the valve of Guérin—lies just within the meatus in the upper wall of the fossa navicularis, and a surgeon always introduces a curved catheter into the urethra, with the point directed towards the floor of the canal in order to avoid this pouch. The ducts of Cowper's glands open upon the floor of the spongy portion of the urethra close to the membranous part. The openings are usually bilateral, and at the same level, but one duct sometimes opens in advance of the other, and occasionally they unite to form a single orifice. The membranous portion of the urethra is of great surgical importance, and, with the exception of the urinary meatus, it is the narrowest part of the urethra. It extends from the apex of the prostate to the bulb of the corpus spongiosum, and lies between the two layers of the triangular ligament, passing beneath the arch of the pubes, from which it is separated by the anterior fibres of the compressor urethræ, and by the dorsal vessels and nerves of the penis. The urethra is curved in this situation, the lower wall being convex downwards and separated from the rectum by the triangular space of the perinæum. The mucous membrane of the membranous portion of the urethra is thrown into longitudinal folds, and contains numerous small mucous glands—the glands of Littré.

The prostatic portion passes from the bladder through the prostate from base to apex. It is about an inch and a quarter in length, and contains the verumontanum upon which are the openings of the utricle and the ejaculatory ducts, whilst on either side is the prostatic sinus into which open the many little ducts from the lateral lobes of the prostate. This portion of the urethra is the widest, and is capable of the greatest dilatation.

The Female Urethra is somewhat fusiform in shape, and in the adult is about an inch and a half in length. It opens within the vulva behind the clitoris, but in front of the vaginal orifice, the urinary meatus being the narrowest and least dilatable part of the canal. The inner surface of the urethra, as in man, presents numerous crypts of Morgagni, which are largest and most numerous near the meatus. There are also many urethral glands varying in complexity from simple depressions in the mucous membrane to true glands of the compound tubular type. Similar glands are found in the vestibule just outside the meatus, where they are called periurethral glands. The periurethral glands are scattered over the mucous membrane, but collectively they are the homologue of the prostate in the male, and calculi are sometimes formed in them. The canals of Skene are two small ducts which open upon either side of the posterior wall of the urinary meatus; they are present throughout life, but increase in size during pregnancy, and are said to attain their maximum size at the time of labour.

ABNORMALITIES.—The urethra is developed from the uro-genital sinus by a complicated series of changes which allows plenty of scope for the production of various malformations. The changes are more complete in the male than in the female, and abnormalities are consequently seen more often in boys than in girls. Imperforate urethra, either partial or complete, absence of a part or of the whole urethra, double urethra, anomalous dilatation, pouchings of various kinds, and recto-prostatic communications are the less common malformations met with in practice. Hypospadias and epispadias are the most frequent and most important.

Hypospadias.—The condition of hypospadias is due to defective closure of the urethra, which may open on the under surface of the penis at any point between the perinæum and the glans penis. The slighter cases are the more common, for the hypospadias is generally limited to the anterior part of the penis, but the condition is often associated with considerable deformity of the penis, which is curved downwards during erection, or may be twisted upon itself in such a manner as to render it useless for sexual purposes. The glans, too, is often flattened; there is no frænum, and the prepuce is long, thickened, and hooded over the imperforate glans. Some of the native tribes in Australia purposely produce hypospadias by opening the urethra at the root of the penis to limit the population.

Treatment.—Operative measures are designed to remedy the deformity of the penis rather than to restore the defective urethra, for extensive plastic operations have been uniformly unsuccessful in my hands. An operation is performed most satisfactorily upon a patient aged 8 to 10 years, and when the orifice of the urethra lies just behind the corona the skin on the under surface of the penis is divided, and retracted until the urethra is freely exposed. The unclosed portion of the urethra is then dissected away, and the tubular portion is freed from its attachments until it can be drawn up and sutured in place of the defective portion which has been cut away; the skin is then brought together with interrupted sutures. In the more severe cases an attempt is made to remedy the deformity of the penis, and to render it capable of erection rather than to cure the hypospadias. And the patient is well content with the operation if this end is attained, especially if the nature of the operation be explained to him beforehand, since he is generally above the age of puberty. The skin on the under surface of the penis is divided, all bands of adhesion are dissected away without cutting into the corpora cavernosa, and the urethra is divided at the point where it forms a complete tube. The cut end of the urethra is then attached to the skin, so that the urethra opens on the under surface of the penis at a somewhat lower level than before; any redundant prepuce is removed at the same time, and the circumcision is completed in the usual manner.

Epispadias is that condition of the penis in which the urethra is defective dorsally. The fissure is often limited to the glans penis, but in the more severe cases the whole penile urethra remains as an open channel, a condition which may be associated with ectopia vesicæ. Little or nothing can be done to remedy these extreme cases, though the urethra has sometimes been drawn through the scrotum partially to close the canal. In other cases I have separated the mucous membrane from the skin along each side of the cleft, and have afterwards sutured it with fine catgut over a black rubber catheter of appropriate size, the edges of the skin being then brought together with sutures of silkworm gut. The anterior part of the epispadias may be closed in this manner, but the posterior part usually remains open even after several subsequent operations.

Inflammation.—Inflammation of the urethra, like inflammation elsewhere, is due to a variety of causes, some mechanical, but the majority due to the action of micro-organisms. The mechanical causes leading to urethral inflammation, both in the male and female, are injury produced by foreign bodies passed along the urethra from without, or by calculi, whole or in fragments, passing from within. Irritating urine may produce urethritis, either because it contains crystals as in oxaluria, or because it holds in solution such drugs as cantharides, turpentine, or squills. Urethritis, too, may be a troublesome symptom in gout, rheumatism, and herpes. The introduction of dirty sounds, catheters, and other surgical instruments is a fertile source of a urethral inflammation, which may become purulent, and may be attended with serious and even fatal results in an unhealthy person. Reference has already been made to urethral inflammations produced by syphilis (vol. xii. p. 7), and by soft sores (Art. "VENEREAL DISEASE," vol. xiii. p. 305).

The symptoms in these cases of urethritis consist in a smarting pain, when urine is passed, and the appearance of a discharge which is either serous or purulent.

The treatment consists in removing the cause, and rendering the urine as little irritating as possible. The patient may be ordered lactate of soda, 10 grains of urotropin, dissolved in half a pint of water, the dose to be repeated three times a day; or he may be given a mixture containing potassium nitrate, 10 grains; bicarbonate of potash, 20 grains; tincture of henbane, 30 minims; and chloroform water to an ounce. Simple and unirritating urethral injections will also afford relief, *e.g.* a teaspoonful of Condy's fluid in a pint of hot water, or 10 grains of subnitrate of bismuth in an ounce of water at 100° F.

GONORRHŒA.—A clap is the commonest form of venereal disease affecting the male urethra. It is an infective inflammation of the urethral mucous membrane, due to the inoculation of the micrococcus gonorrhϾ, or gonococcus, first described by Neisser in 1879. The primary infection in both sexes occurs commonly at some part of the urethra; in the male at the lacuna magna, rapidly spreading to the bulbous portion, or to the prostatic part of the urethra; in the female the anterior part of the urethra, the periurethral glands, the glands of Skene and of Bartholin are chiefly affected at an early period, whilst the cervical canal of the uterus is a usual seat of inoculation, the vagina only becoming affected by the extension of the suppurative inflammation.

Pathology.—Gonococci, like the poison of syphilis (vol. xii. p. 4), can only be inoculated upon the human subject, for no experiments hitherto have succeeded in transmitting either gonorrhœa or syphilis to animals. The gonococci are minute organisms shaped like coffee-beans, which can only be studied under the highest powers of the microscope (one-twelfth immersion lens and upwards). They are generally arranged in pairs with the flattened or concave surfaces adjacent to each other, but they multiply rapidly by fission, so that tetrads and multiples of four are frequent in the colonies. The organisms are always pyogenic as they occur in the urethra, though it is clear that they are not necessarily associated with the formation of pus, because when they attack the tissues secondarily, as in gonorrhœal synovitis, suppuration is often absent. The gonococci gain access to the tissues through abrasions of the superficial epithelial cells, and are passed along the superficial intra-epithelial lymphatic plexuses until they reach a leucocyte. The white corpuscles seem to have a special affinity for them, and the gonococci multiply much more readily in their substance than in the protoplasm of the epithelial cells. The micro-organisms do not penetrate at first beyond the layer of unstriated muscle which bounds the urethral mucous membrane, but the irritation which they cause produces a serous exudation in the surrounding connective tissue and a loosening and detachment of the neighbouring epithelial cells. Pyogenic organisms then add their destructive agency to that of the gonococci, and the connective tissue becomes infiltrated with pus whilst the capillaries may be thrombosed.

The diagnosis of gonococci must be undertaken with due caution, for Mr. Foulerton has shown that eighteen different species of micrococci have been isolated from the healthy or diseased urethra in the male in addition to the ordinary pyogenic cocci, and a mistake in diagnosis may lead to irreparable disaster. The three characteristics by which gonococci are known are:—(1) The occurrence in the pus cells from the urethral discharge of paired organisms shaped like coffeė-beans; at least four pairs should be recognised in each cell. (2) The typical cocci should be readily decolorised when treated by Gram's method. (3) Pure growths cannot be subcultured on gelatin at 20° C., or on agar either at 20° C. or at 36° C., since the other micrococci from the urethra are said to grow at these temperatures and on these media.

Preparation and Staining of Film.—Take two clean square cover slips and place a minute drop of the secretion to be examined upon one slip. Place the other cover slip accurately upon it, and then slide the two apart to obtain a couple of "smear preparations." Place the cover-glasses edgeways until they are dry, and then put them for fifteen minutes into a mixture of equal parts of absolute alcohol and ether to coagulate the albumin and allow the film to be stained and washed without destruction. Filter on to each film surface sufficient anilin gentian violet (which can be bought ready-made or in soloids) to completely conceal the cover-glass. Pour off the stain in fifteen minutes, dip each cover-glass for an instant into water, and then pour on Gram's solution of iodine (iodine one part; potassium iodide two parts; distilled water 300 parts). Pour off the iodine in two minutes, and without further washing, place the cover-glass in a watch-glassful of absolute alcohol until no more violet colour comes away, when the cover-glass is drained on a piece of white filter paper, but not necessarily until the film is decolorised. This usually takes from five to ten minutes, and it may be necessary to employ a second watch-glassful of spirit. Wash in water, dry, and mount in Canada balsam, or counterstain for forty-five seconds in a saturated aqueous solution of Bismarck brown, diluted with three times its volume of water. The pus corpuscles may be stained with eosin and the gonococci with Löffler's methylene blue by putting a film into methylene blue for one minute, washing till most of the blue disappears; counterstaining in a watery solution of eosin for twenty to thirty seconds; washing, drying, and mounting in Canada balsam. The preparation in each case must be examined with an immersion lens.

Course—In Men.—Gonorrhœa is nearly always caught by direct infection and usually during sexual intercourse. The incubation varies from three to five days, though it may be as short as a few hours, and is said to have been as long as a fortnight. The poison is less easily inoculated than that of soft sores, and its incubation period is longer (see Art. "VENEREAL DISEASE," p. 305).

The earliest symptoms are those of a simple urethral inflammation, a sense of heat and itching in the glans penis, with increased sexual excitability and smarting on passing urine. These symptoms increase in intensity, until in twenty-fours the urethral mucous membrane becomes swollen and begins to discharge a secretion which is at first serous but soon becomes purulent. The acute stage is marked by painful erections which may culminate in chordee, when the penis is abnormally curved or bent during erection as a result of plastic exudation into the corpus spongiosum or into one of the corpora cavernosa. Vesical tenesmus and increased frequency of micturition are also frequent and troublesome symptoms. The acute stage lasts about a fortnight, and is often associated with much mental depression. It may be complicated by cystitis and by a sharp and painful inflammation of the epididymis. As the acute stage gradually subsides the discharge becomes thinner, scantier, and clearer, until it either disappears altogether or is merely present as a drop at the meatus on first waking in the morning. An acute attack of gonorrhœa may thus run its course in five to eight weeks, and although this occasionally happens, it is much more usual for the inflammation to undergo a series of relapses which greatly retard recovery, or it becomes chronic as a gleet. The prognosis, therefore, is not very good as regards a speedy cure, though with care and attention there is but little doubt that a gonorrhœa can be wholly cured.

The patient needs to be warned on several points in regard to his cure. He recognises clearly enough that gonorrhœa is contagious, but he does not always understand that it is auto-inoculable. He should be told, therefore, of the danger of carrying infection to his eyes or mouth by rubbing them when his fingers are soiled with the urethral discharge. He must also be told that relapses are produced by very slight indiscretions in eating and drinking, as well as by every departure from strict continence. The dangers of marrying with an uncured gonorrhœa, even though it be very chronic, should be pointed out, and he should be made aware of the fact that it is extremely difficult to determine when a cure has been effected. The gonococci have a remarkable faculty of lying dormant until they are roused into activity by any cause leading to an increase in the blood or lymphatic supply of the urethral mucous membrane. They are especially liable to remain in the follicles of the prostate, so that the prostatic threads passed at the end of micturition should always be carefully examined, and no patient should be pronounced free from gonorrhœa until a careful bacteriological examination has been made of the urethral discharge produced by the injection of a solution of nitrate of silver. The patient is first asked to pass his urine, and 10 drops of a four per cent solution of cocaine hydrochlorate are then injected into the urethra. Five minutes later a solution of nitrate of silver (20 grains to the ounce) is injected into the urethra, the penis being compressed at a point 2 inches behind the meatus, to prevent the fluid passing into the bladder. The solution is retained for a few seconds before it is allowed to escape, and the injection is thrice repeated, after which the penis is washed in warm water. The nitrate of silver causes an acute but temporary desquamative urethritis with considerable discharge, and if the patient is to be pronounced free from gonorrhœa, the discharge should not contain any gonococci. A more rough and ready way of endeavouring to ascertain whether a patient is cured of gonorrhœa is to ask him nearly to empty his bladder. The prostate is then manipulated through the rectum, and the remainder of the urine is then passed. This residue will contain a considerable quantity of the prostatic secretion, and if this is free from gonococci, the patient is perhaps cured.

In Women.—The symptoms of acute gonorrhœa are usually much less severe in women than in men, but the sequelæ and complications are more serious. The inflammation begins as a urethritis which soon involves the vulva and the uterine cervix. The bladder often becomes inflamed quite early in the acute stage in consequence of the shortness of the female urethra.

The symptoms chiefly complained of are tenesmus and scalding during micturition, and an examination of the vulva shows it to be in a state of acute inflammation with a purulent discharge from the orifice of the urethra. The acute stage passes off in the course of a few days, when the inflammation tends to become chronic. The chronic state lasts many months, and as it gives rise to few symptoms it may pass almost unnoticed. Pressure through the vagina along the course of the urethra will cause a little exudation of muco-pus which may contain gonococci in the earlier stages, though it is often sterile when the discharge is of long standing. Gonorrhœa in some women appears to pass at once into a chronic state without any markedly acute symptoms, so that when the patients afterwards suffer from chronic pelvic inflammation, they are unable to assign a definite beginning to their trouble.

In female children gonorrhœa takes the form of a vulvo-vaginitis, though it should be understood quite clearly that every discharge from the vulva and vagina of a little girl is not due to gonorrhœa.

Complications.—The complications of gonorrhœa common to both sexes are cystitis, though the symptoms of this trouble in men are often due to an inflammation of the posterior urethra (p. 62), the bladder itself not being involved; lymphangitis; bubo; urethral abscess; synovitis, which may lead to disorganisation of the joint, but does not usually do so; tenosynovitis, flatfoot; conjunctivitis, endocarditis, more rarely pericarditis or myocarditis, and meningitis; gonorrhœal peritonitis affects women more often than men; pyæmia is somewhat more frequent in men than in women, possibly because it is not very unusual to have a septic thrombosis in the prostatic plexus of veins.

The complications occurring in men are balanitis or inflammation of the surface of the glans penis; phimosis; paraphimosis; acute and chronic inflammation of Cowper's glands, of the prostate and of the vesiculæ seminales; epididymitis, and more rarely true orchitis, or inflammation of the body of the testicle.

The complications peculiar to women are inflammation of the numerous glands lying in the immediate neighbourhood of the urethra, chief amongst these are Skene's glands; the endo- and para-urethral mucous follicles; the vestibulo-vaginal glands and the glands of Bartholin. The gonococci often linger for long periods in these recesses, where they give so little trouble that an apparently healthy woman is able to spread the disease through their secretions. The more serious complications are associated with acute and chronic inflammation of the pelvic organs and of the connective tissues surrounding them, foremost amongst these being metritis, salpingitis, perimetritis, and pelvic cellulitis.

The sequelæ common to men and women alike are sterility; stricture of the urethra, and less commonly of the ureters; hypertrophy of the bladder and pyelitis; urinary abscess; extravasation of urine; urinary fistula.

Treatment.—The treatment of gonorrhœa is both important and difficult. In an ideal state the early and happy marriage of every male would abolish the disease in a single generation; but as this is impracticable, it should be remembered that a diseased woman is more likely to infect a drunken man, and one who has repeated connection than another who takes his pleasure more soberly; that one attack of gonorrhœa predisposes to others, and that even slight sexual indulgence, though it be with a healthy woman, is able to reawaken the acute symptoms in a man who has only been partially cured of the disease. Gonococci deposited upon a mucous membrane are more likely to gain access through an abraded than through a healthy surface, but they do not pass into the lymphatics instantaneously. Washing and micturition immediately after a suspicious coitus may therefore remove them; injections are less to be relied upon, for they may wash the micro-organisms into the urethra, and may act adversely by injuring the surface epithelium of the urethral mucous membrane.

The first symptoms of infection show that the time has arrived for the adoption of more active measures, and it may be premised that those who can rest and modify the routine of their lives are more amenable to treatment, and are less likely to suffer from complications and sequelæ, than those who continue their usual avocations. The hygiene of the acute stage consists in bodily rest, low diet, the avoidance of stimulants, regulation of the bowels, and cool sleeping rooms. The urethra should be freed as far as possible from the secretion, and where the older surgeons were content to effect this object by flushing and by stimulating injections, modern surgeons endeavour to soothe the inflamed parts and to render the discharge sterile. Nitrate of silver was formerly used to a large extent in the treatment of gonorrhœa from its earliest to its latest stage, but various organic compounds of silver are now being adopted with beneficial results. Protargol is the most widely used, itrol or citrate of silver, and albargin, a preparation of silver nitrate and gelatose, are more recent forms. The advantages claimed for these salts over the nitrate of silver are that they are less painful; that they are markedly destructive to gonococci, and that they penetrate the urethral mucous membrane without injuring it or causing irritation. The disadvantages are the instability of the substances which causes them to decompose on warming and even on exposure to light.

Injections should be ordered as soon as the discharge is recognised. They should consist of a half per cent solution of protargol given thrice daily, the morning and mid-day injections being retained for ten to fifteen minutes, and the evening one for twenty to thirty minutes. These injections may be increased in strength to three per cent of protargol, and they are to be continued until the discharge is free from gonococci. The protargol is then to be replaced by an astringent injection, *e.g.*, subnitrate of bismuth, 10 grains; tincture of opium, 10 minims; tincture of catechu, 15 minims: distilled water to three ounces. Urotropin to the amount of 10 grains, three times a day, dissolved in half a pint of water, may be given throughout the disease, replacing the older treatment by copaiba and sandal-wood oil.

Chronic gonorrhœa used to be called gleet, but the symptoms are now known to be associated with a chronic inflammation of the anterior or posterior urethra. The morning drop at the urinary meatus is often the only symptom of chronic anterior urethritis, though the urethroscope shows numerous localised patches of hyperæmia or erosion even as low as the bulbous portion of the canal, whilst the passage of a sound may demonstrate a stricture of large calibre.

The treatment of chronic anterior urethritis consists in healing the erosions, curing the catarrh, and dilating the commencing stricture.

Chronic posterior urethritis shows itself by the recurrence of the discharge after apparent cure without sufficient cause; by attacks of epididymitis long after the period of infection; by prostatic inflammation and spasm of the compressor urethræ muscle many months after the cessation of treatment; by pain of a vague and neuralgic character in the genito-urinary tract, and by sexual hypochondriasis, which is often so marked that Ricord is reported to have said jestingly he expected the retribution for his ill-spent life would be the peopling of his everlasting abode with importunate patients suffering from a gleet with this symptom.

The treatment of posterior urethritis consists in reawakening an acute inflammation in the affected part in the hope that the thickened tissues may thus be restored to their natural condition. This is best effected by the local application of silver nitrate, sulphate of copper or thallin, the latter in a two per cent solution. The application must be applied locally and skilfully, neither in front of the compressor urethræ nor too far back, lest it enter the bladder. The nitrate of silver and sulphate of copper solutions vary in strength from one to ten per cent, according to the tolerance of the patient. When the prostate is involved the patient should be placed recumbent. The meatus and glans penis are then cleansed with a solution of protargol, the anterior urethra is filled with a $\frac{1}{2}$ to $\frac{3}{4}$ per cent solution of cocain, after which from five to ten ounces of protargol solution should be injected into the bladder to be afterwards passed voluntarily by the patient. The injection may be repeated three times a week unless there are symptoms of local inflammation.

Treatment in Women.—The patient should be kept in bed on a milk diet during the acute stage, the bowels being regulated by saline aperients. The genital organs at first should be irrigated frequently with warm solutions of boroglyceride (which is prepared by heating together in a water bath 2 parts of boric acid and 3 parts of glycerine) of the strength of a drachm to the pint. Injections may be used as soon as the acute symptoms have subsided. A four per cent solution of protargol: 1·5000 of biniodide of mercury or 1·4000 of formaldehyde form useful and efficient injections. They should be employed whilst the patient lies upon her back, and when mercurial injections have been used the vagina should afterwards be washed out with a warm salt solution, because in many women there is a tendency for a pool of solution to remain in the vagina so long as they lie on their backs, and from this pool an undesirable amount of absorption may take place. The vaginal douche, however, is only an accessory to the thorough application of a strong solution of protargol or of nitrate of silver to the whole of the affected mucous membrane. This application is made by placing the patient in a semi-prone position, and using a duck-bill speculum. The mucous membrane is wiped clean, and the silver nitrate solution of the strength of 20 to 60 grains to the ounce—or of a ten per cent solution of protargol—is applied with a swab. Especial attention is devoted to the urethra, Skene's glands (p. 56), the ducts of Bartholin, and the cervix uteri. The urethra and canal of the cervix are best treated by instillation of the solution: Skene's and Bartholin's glands by injection through a small syringe with a slender nozzle. A five to ten per cent solution of ichthyol glycerine may be applied on pledgets of cotton-wool, which should be left *in situ* during the intervals between the application of the germicidal solution. Curetting and douching of the uterine cavity should only be employed in the most advanced and chronic stages of the disease, lest the local inflammation set up by the operative measures should lead to the extension of the inflammation to the Fallopian tubes and ovaries.

TUBERCULOSIS OF THE URETHRA.—Tuberculosis of the urethra is always secondary to infection of other parts. It affects the urethra either as an inflammation of the mucous membrane—urethral tuberculosis—or as an inflammation of the connective tissue surrounding the urethra as it lies in the perinæum, or more strictly localised to the prostatic urethra-tuberculous periurethritis. As in other mucous membranes the tubercular inflammation manifests itself in the form of chronic inflammation, miliary tubercles, shallow but circular ulcers, or caseating deposits. The inflammation has occasionally been followed by stricture. The symptoms are those of an ordinary chronic urethritis: a muco-purulent discharge, increased frequency of micturition, sometimes with pain and sometimes associated with the passage of blood. Treatment consists in administering cod-liver oil, the ordinary hygienic measures now in use for the treatment of phthisis, and the removal of the discharge by unirritating urethral injections. Urotropin may be administered to keep the urine acid (grs. x three times a day in half a pint of water), and iodoform bougies are often of service in the local treatment of the urethritis.

Stricture of the Urethra.—True stricture of the urethra—the *organic stricture* as it is often called—is a narrowing of the urethra caused by a proliferation of inflammatory cells in the submucous tissue, the cells becoming converted into scar tissue which afterwards shrinks. Any chronic inflammation of the urethra therefore may lead to a stricture, and the commonest forms of inflammation are gonorrhœal; injury due to external violence, to the passage of instruments or calculi along the urethra; soft sores, chancres and phagedæna. Acute retention of urine is sometimes caused by a temporary narrowing of the canal due to inflammatory swelling of its walls—*inflammatory stricture*—and sometimes from spasm of the muscles surrounding the canal—*spasmodic stricture*. Inflammatory stricture is the result of acute urethral inflammation, of direct injury to the mucous membrane, and it is often associated with an old-standing organic stricture. Spasmodic stricture is usually reflex in character, and it causes the retention of urine so often seen after the operation for piles, and after injury to the perinæal region even though the urethra has not been hurt. Like the inflammatory stricture, this reflex spasm of the urethral muscles is often associated with an organic stricture.

Symptoms.—The symptoms and their severity vary greatly in different people, but the most marked, and that which most often brings the patient to a surgeon, is some alteration in the flow of urine. The stream, instead of passing at once in a full flow and stopping completely, presents various modifications. It is often smaller than usual, and may be twisted or forked. The act of micturition takes longer, it is more frequent, and it is painful. The last few drops of urine can only be expelled by straining, and even then the urethra is not completely emptied, for the patient complains that the urine dribbles away, and that his trousers get wet if he is at all in a hurry. There is often a slight muco-purulent discharge from the meatus associated with the presence of erosions of the urethral mucous membrane in the immediate neighbourhood of the stricture. The outflow of semen is retarded in the same manner as that of the urine, and various difficulties arise during intercourse which lead in many cases to a condition of sexual hypochondriasis.

Sequelæ.—Many strictures remain untreated, sometimes because they are unrecognised, but usually because the patient is too careless to undergo the prolonged course which is necessary to cure them. The sequelæ, therefore, are numerous and well recognised. The urethra immediately behind the stricture becomes dilated and ulcerated; a calculus may be lodged in this portion of the urethra, or it may yield and allow of the extravasation of urine into the scrotum and beneath the deep layer of the superficial abdominal fascia. More frequently, however, only a few drops of decomposing urine leak through the softened mucous membrane, and a perinæal abscess is formed leading to a urinary fistula.

The prostate may become congested by the chronic inflammation, and it may either be hypertrophied or suppurate.

The urine does not pass freely out of the bladder, which in consequence is often incompletely emptied. The urine decomposes, and a condition of chronic cystitis is set up with a deposit of mucus and phosphates which may give rise to such discomfort as to require the performance of a perinæal section. The additional force needed to expel the urine through the narrowed urethra is obtained by hypertrophy of the muscular walls of the bladder, but eventually this hypertrophy ceases, and the bladder becomes thinner whilst its mucous membrane is pouched, the pouches often acting as traps where small calculi may grow into larger ones.

The hypertrophy of the bladder prevents the easy passage of urine along the ureters which in consequence become dilated and tortuous, whilst the backward pressure acting upon the pelves of the kidneys causes them to dilate. Hydronephrosis results, and if the urine becomes purulent a multiple suppurative nephritis or surgical kidney ends the life of the patient.

Diagnosis.—The only means of determining whether a patient has a stricture is to pass an instrument, and the proper instrument to pass is a bougie and not a catheter. The acorn-headed black bougies are the best for exploratory purposes. A No. 12 English should first be passed, and care should be taken that it is absolutely clean, quite supple, and well lubricated. Glycerine or castor-oil will be found more useful than vaselin or lanolin. The patient should be recumbent on a couch, the surgeon standing upon his right side. The instrument is passed onwards deliberately, continuously, and without using any force, and it should be withdrawn as slowly and gently as it has been passed. The instrument will pass into the bladder with the greatest ease if there is no stricture, though the patient may complain of a little smarting or even faintness as it passes through the triangular ligament, and of a desire to pass water when the end of the bougie touches the trigone. If a stricture be present the bougie will be more or less completely arrested during its passage, the actual seat of arrest being situated most often at the bulbo-membranous part of the urethra, the next commonest seat of stricture being within two inches of the urinary meatus; whilst the prostatic urethra is only strictured as a result of direct injury. Strictures are often multiple, and when this is the case the posterior stricture is usually tighter than the anterior. An attempt should be made to ascertain the size of the stricture as soon as its position has been determined. This estimation is made by passing a black olivary bougie of large size, and replacing it by successively smaller sizes, until an instrument can be passed through the stricture; and it is always advisable to begin with a large bougie and work downwards rather than to begin with a small size and work up to bigger ones, since by this method it is easy to underestimate the size of a stricture, because the passage of successive instruments causes spasm or congestion of the injured urethra.

Treatment.—A stricture sometimes leads to acute retention of urine, even though it has not previously been troublesome. Such a condition is readily caused by anything which will produce a temporary congestion of the urethral mucous membrane or a reflex spasm of the muscles surrounding the urethra, or even of the muscularis mucosæ itself. A hot bath and a full dose of Dover's powder will often enable a patient to pass his water in such cases, but if these measures fail, the passage of a No. 8 or 9 black olivary catheter can generally be readily effected if the instrument be passed gently but continuously and rather quickly along the urethra, for any jerky movement or any bungling or uncertainty on the part of the surgeon will increase the spasm.

The broad principles to be grasped in the treatment of an organic stricture are, first, that the canal of the urethra be sufficiently enlarged to allow of the free flow of urine, and, secondly, that its calibre should afterwards be maintained. The urethra is restored to a sufficient size either by instrumental dilatation or by division of the strictured portion. Dilatation is the better method in most cases, though it has well-marked limitations. Some patients are quite unable to tolerate the passage of instruments; in others the stricture contracts again as quickly as it is dilated—*resilient stricture;* other strictures are so firm and gristly as to be incapable of dilatation, whilst others again are practically impermeable. As a general rule strictures situated within the meatus are better divided than dilated.

Dilatation is performed either gradually or continuously, gradual dilatation is the method most often employed at the present time, because it does not oblige a patient to discontinue his ordinary avocations. A clean black olivary bougie is passed through the stricture, of as large a size as can be introduced, and is immediately withdrawn, the patient being told to come again for a second sitting after an interval of five or seven days. At the next interview a bougie of the same size as the one last passed is again introduced, and when it is withdrawn it is replaced by the next size larger. A similar method is followed on successive occasions, until a No. 10 English can be readily passed into the bladder. Further dilatation to admit a No. 15 or 16 English is accomplished by the use of a highly polished and conical steel sound, whose curve is graduated through four sizes of the French gauge from the point to the thickest part. The patient should be told that it may take from five to six months to dilate a moderately tight stricture, but he has the satisfaction of knowing that when the dilatation is fully accomplished the occasional passage of a full-sized instrument will be sufficient to prevent recontraction. The directions I usually give to a patient who has been treated by gradual dilatation are to pass a bougie every Sunday morning for three months from the time he last sees me; on every alternate Sunday for a further period of six months; then once a month for nine months; and finally on every quarter day, but he is not to feel satisfied unless he can continue to pass the full-sized instrument on each occasion. The rationale of the cure is not fully understood, though there is little doubt that it acts by altering the blood and lymph supply in the affected part of the mucous membrane.

Sizes of Catheters and Bougies.—The sizes of English catheters and bougies are purely empirical, for they differ slightly according to the maker. They are numbered from 1 to 12, and correspond roughly with Nos. 3 to 21 of the French scale. The filière Charrière of the French notation is the more satisfactory, as it is based on a scientific system. It extends from 1 to 30, each number denoting the size of the circumference of the instrument in millimeters, thus No. 1 catheter or bougie measures one millimeter or one-twenty-fifth of an inch round, No. 6, six millimeters, and so on.

Continuous dilatation is less often employed. It consists in putting the patient to bed, introducing a catheter into the bladder, and tying it in for twenty-four hours, when it is replaced by another two or even three sizes larger than the first. It is often more comfortable for the patient if the catheter first tied into the bladder be a size smaller than the stricture admits readily. The catheter must be removed if the patient has a rigor and if, without a shivering fit, he becomes feverish. The end of the catheter should only lie just within the bladder, and for this reason the ordinary red or black rubber catheters are better than the olivary catheter whose eye is necessarily at some distance away from the end. The urethra should be gently irrigated with a 1 : 10,000 solution of biniodide of mercury, at a temperature of 100° F. every time the catheter is changed. The treatment usually lasts a fortnight, and the patient is confined to his bed. The after-treatment is the same as after the continuous method. Continuous dilatation is used when the interrupted method has failed, when the patient has only a limited time at his disposal, as in the case of an officer on leave or a mate at home between two voyages, when the stricture is complicated with a cystitis which renders it advisable to drain the bladder, and as a preliminary to internal urethrotomy.

The operative treatment of stricture is conducted on the same lines as that of dilatation. The urethra is restored to its natural size by division of the constriction, and it is afterwards maintained at this size by the passage of instruments. The mere division of a stricture without adequate after-treatment is useless. Two methods of operative treatment are in use at the present time. Division of the stricture from within the urethra or internal urethrotomy, and division by cutting through the penile or perineal structures from without—external urethrotomy. Both methods have their strong advocates, but neither can be employed to the exclusion of the other. Internal urethrotomy requires that the stricture shall admit some instrument as a guide to the urethrotome, whilst external urethrotomy compels the patient to remain in bed for a considerable length of time.

Internal Urethrotomy.—The cases suitable for internal urethrotomy are those in which the stricture is situated close to the urethra, narrow and well-localised strictures, *e.g.* annular and bridle strictures, strictures in which dilatation has been tried and failed, either because they are resilient (p. 65), or because they are too fibrous or gristly. It is undesirable to operate in this manner upon patients who have an infective urethritis.

Internal urethrotomy is performed according to Civiale's method, in which a concealed knife is passed through the stricture, and the constriction is divided from behind forwards, or it is done by Maisonneuve's method, in which the incision is made from before backwards by a blade running in a metal guide, the knife being passed along a groove in the guide which is first introduced through the stricture.

When Civiale's method is adopted the stricture is continuously dilated until a No. 5 English catheter can be passed. This catheter is left in until the time of the operation when it is withdrawn, and the urethra is carefully cleansed by irrigation with a solution of biniodide of mercury (1 : 5000) at a temperature of 100° F. The sterilised urethrotome is passed along the urethra until the surgeon is satisfied that it has entered the bladder. The instrument is withdrawn until the bulb touches the posterior edge of the stricture, the cutting edge of the knife being directed towards the floor of the urethra. The blade is then projected to the required distance, and is drawn smartly through the stricture until it is fully divided, when the knife is retracted into its sheath before the urethrotome is withdrawn. If the strictures are multiple they are all divided at the same sitting. A steel director is afterwards passed along the urethra to determine whether the strictures have been satisfactorily divided, but not to dilate, for if it does not pass easily, the urethrotome must be reintroduced. The bladder is then washed out with a saturated solution of boric acid, at a temperature of 110° F., and the patient is directed to retain his urine if possible for a period of eight hours.

If Maisonneuve's method is adopted it is usual to employ Tevan's modification. A filiform guide-bougie with a screw top is first passed through the stricture, and the thin grooved staff of the urethrotome is screwed on to it and passed on through the stricture. The staff is held steadily, and the *bistouri caché* is passed along the groove until its hood is arrested by the stricture. The constriction is then divided by a series of short cuts with the knife, the blade being allowed to recoil between each cut until the stricture is divided. The subsequent steps are the same as in the previous operation. In either case it will be sufficient to begin dilatation with a catheter on the tenth day after the operation.

External Urethrotomy.—The methods chiefly employed are those of Syme and Wheelhouse, and of these I prefer Wheelhouse. External urethrotomy is required when the stricture is practically impassable, when the stricture is narrow and the bladder requires draining in consequence of long-standing cystitis having filled it with foul urine and deposits of phosphates and mucus. The method is also serviceable when the stricture is complicated with false passages and urinary fistulæ.

In *Wheelhouse's operation* the patient is prepared in the usual manner, his skin at the seat of operation being made as sterile as possible. He is anæsthetised, and placed in the lithotomy position, Wheelhouse's staff being passed along the urethra until its point touches the stricture, the groove on the staff looking towards the floor of the urethra. The surgeon cuts down upon the groove making a skin incision of about an inch and a half in length. The assistant then rotates the staff to engage its hook in the upper angle of the wound, and draws it upwards to stretch the urethra in this position. A pair of pressure forceps are placed upon each edge of the wound to act as retractors, and by this means the urethra immediately in front of the anterior end of the stricture is converted into a lozenge-shaped space. The surgeon takes a fine probe and carefully explores the lower angle of this lozenge to ascertain the position of the urethra, and he may have to explore many false passages before he discovers it. When it is found he passes a probe-pointed director onwards until it lies freely in the urethra beyond the stricture. The stricture is divided by a straight bistoury passed along the groove in the director, and when the division is complete a probe-pointed gorget is pushed along the urethra into the bladder. A full-sized silver catheter is passed through the meatus over the gorget into the bladder, the gorget is withdrawn, the pressure forceps are taken off, and a dressing is applied to the wound which is left unsutured. The catheter is tied into the bladder, but its end is not plugged, as it is important that the urine should run away freely from the bladder. The catheter is retained for three or four days, and after its removal a steel sound is passed every third day until the external wound is completely healed. The after-treatment of the case is the same as that described at page 66.

In Syme's operation the patient is anæsthetised, and the staff is passed before the patient is put into the lithotomy position. The narrow terminal portion is passed through the stricture until its shoulder is stopped, the patient is then trussed, an incision is made exactly in the median line, and is carried through the urethra until the staff is exposed. The stricture is divided by passing a bistoury along the groove in the thin part of the staff. The staff is withdrawn, and a full-sized catheter is passed into the bladder, if necessary with the aid of a blunt-pointed gorget in the wound. The subsequent treatment is that described above (p. 66). It often happens that the patient's condition renders it impossible to keep a catheter in the bladder, and in such cases a piece of catheter may be inserted into the bladder through the perinæal wound, special precautions being taken to prevent the drain dropping into the bladder, as it may then be lost sight of and form the nucleus of a vesical calculus long after the operation.

Cock's operation opens the urethra behind the stricture and without a guide, by cutting accurately in the middle line of the perinæum, whilst the operator has the index finger of his other hand in the rectum. The urethra is opened in front of the prostate and a catheter is passed into the bladder through the wound, is cut short and tied in with tapes. Mr. Jacobson points out that this operation is not easy for one who only practises it occasionally, and that it is a more severe operation than the size of the wound would suggest.

Strictures of the urethra have sometimes been enlarged by forcible splitting, and in other cases electricity has been employed for the purpose of electrolysis, but both these methods have now fallen into disuse.

RUPTURE OF THE URETHRA.—The urethra is readily ruptured by such direct violence as falling astride a bar or from a kick in the perinæum, but it is sometimes the result of indirect violence or it is a complication of fractured pelvis. The rupture is either partial or complete, and may coexist with a mere contusion of the perinæum.

The symptoms are generally severe pain, with greater or less difficulty in passing water. A tense and tender swelling forms in the perinæum, and there may or may not be bleeding from the orifice of the urethra.

The treatment in the slightest forms should be expectant, as it is possible that the urethra may only be bruised. The patient is put to bed, and the swollen perinæum is carefully watched to see that no extravasation of urine or suppuration takes place. The perinæal hæmatoma should be incised if the temperature rises or if there is evidence of extravasation. More usually, however, there is no doubt as to the character of the injury, and the surgeon should then make an immediate attempt to pass a full-sized silver catheter, which should be tied in if he is so fortunate as to be successful. A median perinæal incision should be made if the rupture is associated with much bruising. When it is impossible to pass a catheter the patient should be placed in the lithotomy position, and a grooved staff should be passed along the urethra until it reaches the seat of injury. An incision is then made in the middle line until the staff is exposed, and the ruptured urethra can be explored. It is easy enough to find the anterior end of the torn urethra through which the staff projects, but it may be extremely difficult to find the posterior portion. The search, however, may be rendered easier by remembering that the posterior portion of the urethra in such cases usually lies nearer to the anus than the penile part, whilst pressure upon the bladder may cause a few drops of urine to trickle from the torn end. A catheter should, if possible, be passed from the meatus into the bladder; but if this is impossible the wound may be left unclosed and lightly packed with gauze, for the bladder will tend to empty itself through the torn end of the urethra without any dangerous distension, and a catheter may be passed after a few days' interval. The use of hot fomentations to the perinæum will often be a useful dressing, as it tends to promote the flow of urine. Suprapubic drainage of the bladder may be performed if it is really necessary, the drainage being maintained for about ten days until a catheter can be passed through the urethra.

The prognosis of ruptured urethra, even in its slighter forms, is extremely bad, for the laceration nearly always leads to a most intractable and deeply seated stricture, which makes it necessary for the patient to maintain instrumental dilatation for many years, or even during the rest of his life.

PROLAPSE OF THE URETHRA.—Prolapse of the urethra is not uncommon in little girls as a result of general weakness, local irritation at the neck of the bladder and repeated straining due to a chronic cough or habitual constipation. It is occasionally met with in elderly women associated with senile changes and laxity of the genital passages, and it is seen as a rare accident in healthy women during middle life. The prolapse is generally chronic, but it may be acute.

The symptoms are increased frequency of micturition, with scalding, and the passage of a little blood. Examination of the vulva shows the presence of a red mass which may be furrowed longitudinally, and presents a central depression forming the orifice of the urethra. The prolapse may be mistaken for a nævus, polypus, or urethral curuncle.

Treatment.—Simple replacement is often sufficient to cure the prolapse, especially if the parts be regularly washed with cold water. The occasional application of solid nitrate of silver to the mucous membrane causes sufficient constriction to prevent recurrence in many of the chronic cases. Satisfactory results are also obtained by drawing forwards the prolapsed and œdematous mucous membrane, and then snipping it off.

TUMOURS OF THE URETHRA.—The innocent tumours of the urethra are neither common nor important, and the primary malignant growths are very rare in both sexes. The simplest innocent tumours are found by the urethroscope in the male urethra. They are simply masses of granulation tissue in the neighbourhood of strictures, or associated with chronic inflammations of the urethra. Small polypi are found in the prostatic portion of the urethra independently of any urethral inflammation, and occasionally a villous tumour makes its presence known by hæmorrhage when it is found in the penile portion of the urethra near the meatus. I have seen from time to time a pedunculated fibrous tumour growing from the lips of the meatus.

A urethral caruncle is the best known urethral tumour growing in the female. It is very vascular, is painful when it becomes inflamed, and it often causes increased frequency of micturition. The treatment consists in dissecting it out for mere ligature, and snipping off is useless, as it quickly grows again.

Malignant tumours of the urethra are much rarer than innocent growths. The carcinomata are primary or secondary. Primary cancers in men occur in two forms. A squamous epithelioma growing in old men; it springs from the urethra often at a considerable distance from the meatus, and is to be clearly distinguished from the comparatively common cancer of the penis. A more rare villous carcinoma of the urethra which occurs in younger men, the growth having a histological structure not unlike that of a "duct cancer" of the female breast. This form of tumour spreads rapidly as a destructive papilloma of the penis. Secondary carcinomata involve the urethra by extension from the bladder, prostate and penis in men: from the uterus and vulva in women.

Sarcoma of the urethra occurs in girls and women. It is part of a general sarcomatous growth affecting all the connective tissues, which are involved in the complicated developmental processes associated with the formation of the cloaca. The growth is polypoid in character, and has a greater tendency to ulcerate in the adult than in the child. The prognosis is more favourable in later than in early life, for the growth can be removed more completely in women than in children.

CALCULI.—The first and only symptom of stone in a child may be the acute retention of urine due to its impaction in the urethra, but in adults there is usually evidence of a calculus before it becomes impacted, and the symptoms are much less acute, whilst the retention may be very incomplete. In adults, too, a stone which has thus become lodged in the urethra, especially if it lies in the prostatic portion, may gradually increase in size until it takes the shape of the urethra for an inch or more. Calculi which have been retained in the urethra in this manner for long periods of time are often multiple. In some cases a calculus may become lodged behind a stricture, and may receive successive incrustations of phosphates from the ammoniacal urine passing over it until it attains a considerable size. The presence of such a calculus increases the tendency to ulceration and pouching of the urethra behind the stricture, and is often associated with extravasation of urine or a urinary abscess. The diagnosis of a urethral calculus is not attended with any great difficulty. It can be felt when it lies in the penile portion of the canal, whilst the passage of a sound will usually demonstrate its presence when it is situated nearer the bladder.

Treatment.—When the stone lies near the meatus and is of a regular shape it can be removed by means of a pair of urethral forceps, and when it lies farther back the passage of a sound will often drive it into the bladder whence it should be removed by crushing or suprapubic lithotomy. Prolonged and violent attempts should never be made to extract calculi, as much damage may be done to the urethral mucous membrane. If the calculus cannot easily be withdrawn through the meatus or pushed into the bladder it should be removed by external urethrotomy (p. 67), the incision in the skin and urethra being afterwards sutured in the hope of obtaining union by first intention. It is better, I think, not to tie a catheter into the urethra after the operation unless it is clear that the mucous membrane has been much injured, either by the irregularity of the stone or by the attempts which have been made to remove it.

Foreign Bodies.—Foreign bodies are more often found in the male than in the female urethra because the shortness of the urethra in women allows them to pass readily into the bladder. In both sexes foreign bodies are often passed into the urethra, and show a remarkable tendency to escape from the hold of the patient and to travel rapidly backwards towards the bladder. They usually cause much pain with the muco-purulent discharge characteristic of urethritis, and their presence is easily recognised by the passage of a sound. No general rule can be laid down for their extraction, and the ingenuity of the surgeon may be taxed to the uttermost to remove them with as little injury as possible to the urethra.

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Uric Acid.

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Among the products of nitrogenous katabolism uric acid occupies a very important place, not only because of the appreciable quantity in which it is usually excreted, but also on account of the marked variations in its excretion under pathological conditions. Variations in the excretion of urea, the most important nitrogenous bye-product, do not so readily attract the attention of the clinician as an increase or decrease in the excretion of such an insoluble body as uric acid. The great tendency that it has to separate out from the urine on cooling is noticed even by the individual who has had no medical training, and he rightly associates it with the febrile state and its accompanying diminished renal secretion. Not only do uric acid and its salts tend to separate out from such a slightly acid fluid as the urine, but they also under abnormal conditions are deposited in the alkaline reacting tissues.

In this article special stress will be laid upon the physical and chemical characters, the probable modes of origin, and the relationship to certain important pathological conditions. In studying what may be called the physiology of uric acid, one is brought face to face with some of the most important problems in metabolism, and it is absolutely essential for all who aim at acquiring an accurate knowledge of the changes which nitrogenous foodstuffs undergo after absorption to have a good grasp of the life history of uric acid.

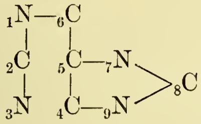
Physical and Chemical Characters.—It is in an impure condition that the acid and its salts separate out from the urine, but when examined free from pigments, etc., it forms a white powder, which may easily be obtained as transparent rhombic plates. In a urinary deposit, however, uric acid is always pigmented, having carried down usually the pigment uroerythrin along with urochrome or urobilin—the so-called "cayenne pepper" deposit. It is always in crystalline form, the appearance of the crystals varying greatly from a lozenge shape, through many intermediate forms, to the barrel shape (rhombic plates or rods, daggers, rosettes, cubes, dumb-bells, etc.) If there be a percentage increase in the amount of urates in the urine, although there may be no deposition at body temperature, a precipitate of a yellow to a reddish brown colour gradually separates out as the urine cools—the "brick-dust" deposit. This, of course, disappears when the urine is warmed above body temperature. In an ammoniacal urine the acid separates out in the form of an acid ammonium urate, sometimes masses of dumb-bell crystals or spherical accumulations of needles. Acid sodium urate, although usually in amorphous form when occurring in a urinary deposit, is now and then met with in crystalline form as spherules with processes—"thorn apple" crystals. In all uric acid or urate deposits the normal pigment of the urine, urochrome, is present as the colouring agent, often but not always associated with uroerythrin.

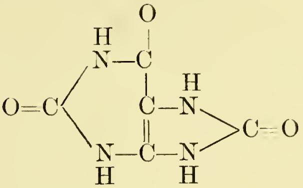
There is a less soluble salt of uric acid than the biurate, namely, the quadriurate, which is formed by the action of the diphosphates of the alkalies on the biurate. This triacid urate ($NaH\overline{U}$, $H_2\overline{U}$) usually occurs in amorphous form, now and then as a gelatinous cloud, which on microscopic examination is seen to be composed of radially striated spheres. It is very easily decomposed, for example, by means of hot water or neutral salt solutions, into the biurate and uric acid if no additional base be present. The biurates separate out either in the form of an amorphous deposit, small spherules, collections of small acicular or prismatic crystals.

In order of solubility the salts of lithium come first, then potassium, sodium, ammonium, calcium, and magnesium. In all cases the neutral salts are most soluble, then the biurates, while the least soluble are the quadriurates. Uric acid is less soluble than any of these, as one would expect, one part requiring approximately 1600 parts of boiling water or 16,000 parts of cold water to keep it in solution. The neutral salts of the alkalies do not occur in the urine as they so rapidly undergo decomposition.

From the formula of uric acid it is apparent that there are two urea residues, with a central three carbon chain, and so it has been termed a diureid of trioxyacrylic acid; but from E. Fischer's researches its constitution has been brought more into line with other important bodies of a similar nature occurring in the organism, the so-called xanthin series.

Uric acid may be regarded according to this nomenclature as a trioxypurin, a derivative of the hypothetical 9C—N ring "purin." Thus,





(Uric acid.)

That is to say, this acid may be regarded as a 2, 6, 8 trioxypurin, xanthin as a dioxypurin, and hypoxanthin as an oxypurin. It is of very great assistance to possess this knowledge of the close chemical relationship existing between these bodies when the physiological connection between them is studied.

As there is, of course, the possibility that in the animal organism there are means of *synthetically* producing uric acid from simpler bodies, it is important to discover how it may be synthetically formed outside the organism. Horbaczewski formed it synthetically from urea and glycocoll, an exceedingly important synthesis from the physiological standpoint.

$$3CO(NH_2)_2 + CH_2.NH_2.COOH = C_5H_4N_4O_3 + 2H_2O + 3NH_3.$$

It was also formed synthetically from trichlorlactic acid, or its amide and urea. Both these syntheses are of great interest, as there is no reason why they should not be carried out in the animal organism.

Thus from a chemical knowledge of the means by which the acid might be formed without the aid of living tissues, investigators began to pay special attention to those substances occurring in the organism from which purin bodies could be obtained, and also to those which might play a part in a synthesis similar to those just mentioned. Physiological work along those lines will be described when the mode of origin of uric acid is taken up.

The final products of decomposition of the acid are carbonic acid, water, and ammonia, but there is a variety of paths along which this disintegration may take place before arriving at the final stage. When peroxide of lead is used as the oxidising agent, the most important products are carbonic acid, oxalic acid, urea, and allantoin; while if nitric acid be employed, urea and alloxan are formed in the first place, then the latter breaks down on heating into carbonic acid and oxalylurea, the latter finally splitting up into oxalic acid and urea.

Tests employed for the Detection of Uric Acid and its Salts

(*a*) The *microscopic appearance of the crystals*, their *pigmentation* with uroerythrin or urochrome, *and their solubility on heating in alkaline solution* are characteristic.

(*b*) They form definite *crystalline compounds with nitric and oxalic acids.*

(*c*) *Murexide Test.*—If a small quantity of the acid, or one of its salts, be placed in a porcelain lid, and then a few drops of nitric acid be added, on careful heating, either on water bath or over small open flame, a reddish coloured residue is left, which gives a purple red colour with ammonia, or a bluish violet with a drop of caustic soda (added when residue is cold). On heating the colour disappears.

(*d*) On heating a small quantity of the acid with an excess of *Fehling* *solution, cuprous oxide* separates out, but if the cupric salt be relative to the uric acid small in amount, then a white precipitate of *cuprous urate* forms.

(*e*) It forms *double salts with magnesium and silver* which possess a characteristic gelatinous appearance. One of the quantitative methods (Ludwig-Salkowski) depends upon this reaction.

(*f*) It is separated out completely from its solutions on *saturation with ammonium chloride* in ammoniacal solution. Another quantitative method (Hopkins) depends upon this reaction.

METHODS FOR URIC ACID ESTIMATION.—There are two which are commonly employed, namely, those of Salkowski and Hopkins, and, as the latter is the more suitable for comparatively rapid clinical work, it alone will be described here.

Take 30 grammes of finely powdered pure ammonium chloride in a beaker, add 100 c.c. of urine, stirring the mixture for some time until solution is complete, then add sufficient ammonia to render it distinctly ammoniacal in odour. Place mixture aside for three to six hours, filter, then wash filter paper with boiling water until all the ammonium urate has been dissolved. Add to this solution sufficient hydrochloric acid to make it slightly acid in reaction, evaporate down on water bath until volume is about 10–20 c.c., then add 1–2 c.c. of conc. hydrochloric acid and leave mixture overnight. After the deposit has been collected on an ash-poor filter paper and washed chlorine free with distilled water (measured amount), then with alcohol and ether, it is finally dried to constant weight at 110° C.

The ammonium urate of uric acid deposit may be titrated with warm sulphuric acid and permanganate solution, but only after all trace of the chloride has been removed by washing.

FORMATION AND EXCRETION OF URIC ACID.—It is to be met with in largest quantity in the excreta of birds and snakes, where it forms the main nitrogenous waste product excreted by the kidneys. In man the excretion varies from 0·2–1 gm., the average on mixed diet being about 0·6–0·7 gm. in twenty-four hours, but under certain abnormal conditions more than 1 gm. may be excreted. It is frequently, but not always present in the urine of carnivora, the amount as a rule being very small; in herbivora it is probably always to be discovered, although also only in small quantity. It has been extracted from various organs, but only in very small quantities, at least in mammals, traces having been detected in the liver, spleen, pancreas, and perhaps also in the normal blood. In the liver of birds it is present in appreciable quantity, certainly more than in the other organs.

The *influence of diet* upon the excretion is undoubted, although the reasons for the effects produced are still subjects of controversy. Flesh diet causes a rise in uric acid excretion, while a vegetable diet is accompanied by a fall. Where there is a breaking down of tissues, especially of those rich in nucleins (proteid substances containing a purin radicle), there is a rise in uric acid relative to the urea. Just as nucleins or their decomposition products derived from tissue metabolism ("endogenous") produce this increased excretion, so also does a diet rich in those proteids ("exogenous"). An increase has also been noticed two to five hours after food has been taken, containing neither nucleins nor purin bases. In the last-mentioned case, of course, the mode of formation may be of the same nature as in the others, namely, the result of nuclein katabolism occurring during the digestion leucocytosis.

The effect of such variations in the diet as increase in the amount of water or alkalies is comparatively slight, and may be explained in various ways, *e.g.* a purely diuretic effect or an increase in nitrogenous metabolism.

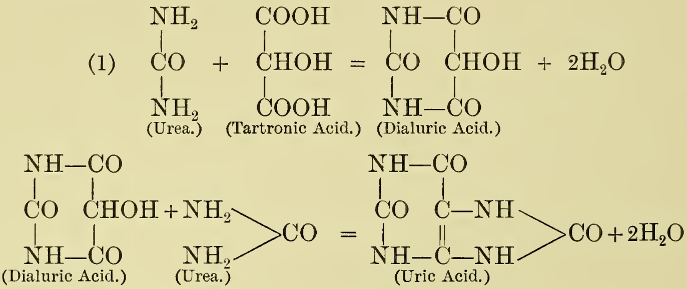
Under mixed diet the ratio of uric acid to urea is from 1 : 50 to about

1:70, but there are often marked variations. In the newly born the ratio is 1:13.

ORIGIN OF URIC ACID IN THE ORGANISM.—Although in all probability the synthetic mode of origin in mammals is of minor importance when compared to the purin source, still it is one which is of great interest, and as it seems to be the main one in birds where uric acid constitutes the principal nitrogenous effete product, it will be taken up first of all. The earlier observations on birds and snakes dealt mainly with the question of the seat of origin, either by noticing the effects of removal of different organs, or by examining various tissues in order to discover whether any particular one was richer in uric acid than the others, and hence more likely to be the seat of origin. Von Schroeder found that even after removal of the kidneys in birds and snakes, uric acid accumulated in the blood and tissues, thus proving at least that the kidneys were not the sole seat of uric acid formation. Meissner found uric acid both in the blood and liver of birds, but most largely in the latter, and so concluded that it probably was the seat of origin. Von Knieriem found that amido-acids, such as glycocoll, aspartic acid, and leucin produced an increase; but neither ammonium chloride, nor sulphate produced an appreciable effect upon the excretion. Subsequently, however, von Schroeder found that, just as in mammals, the only ammonium salts that could be synthetised were those which could be converted into the carbonate in the organism, this being the reason why von Knieriem obtained no effect from giving the sulphate and chloride. The last-mentioned investigator surmised that ammonium lactate might be the important forerunner, but it was not until Minkowski published his very important work that our knowledge of the subject was based on sure experimental evidence. In an elaborate series of experiments on geese he showed that, if the liver were removed in its entirety, practically all the uric acid disappeared from the urine, while its place was taken by ammonium sarcolactate. The reason that he gave for the persistence of a small uric acid excretion even after removal of the liver was that another mode of origin existed, similar to that in mammals, namely, from nuclein sources, and this hypothesis he based upon results obtained by von Mach, who gave, on Minkowski's suggestion, hypoxanthin to geese before and after removal of the liver. He found that under both conditions this purin body could be converted into uric acid.

Although the importance of those investigations can scarcely be overestimated, one must remember that the mere fact that the birds lived for so short a period after the operation (6 to 18 hours), makes the experiments less conclusive than they would otherwise be. Hoppe-Seyler and Araki suggested that the results might be due to the increased production of sarcolactic acid as a result of the disturbance in oxidation processes, and that the rise in ammonia was required to neutralise the abnormal amount of acid. Minkowski answered those objections by showing that an operation of almost equal severity, entailing as great a general disturbance, did not produce an increased sarcolactic acid excretion. Lang showed that after removal of the liver from geese, not only was there an increase in the ammonia excretion, but also a decided rise in the mono-amido acids.

In support of Minkowski's views the author has shown that acids on being given to birds produce a very marked diminution in uric acid and a corresponding increase in ammonia, similar to the effects produced by acids in carnivorous mammals when the urea is replaced in part by ammonium salts. He was unable to find a direct transformation of hypoxanthin to uric acid, at least certainly not to the same extent as von Mach describes, and all his experiments went to prove that in birds the purin mode of origin was of minor importance compared to the synthetic one from ammonium salts (*vide* Wiener). It is possible that the nitrogen of the purin bodies may be split off in some cases in the form of ammonia, and may then, of course, be synthetised. Wiener, in a recent paper on the synthesis of uric acid, refers especially to the nitrogen-free partner in the synthesis, and concludes that tartronic acid may be the body, the process probably running as follows. Tartronic acid unites with one molecule of urea to form dialuric acid, and this in its turn combines with a second molecule of urea to form uric acid, thus—



$$(1)\quad \begin{array}{c}NH_2\\|\\CO\\|\\NH_2\\\text{(Urea.)}\end{array} + \begin{array}{c}COOH\\|\\CHOH\\|\\COOH\\\text{(Tartronic Acid.)}\end{array} = \begin{array}{l}NH—CO\\|\quad\;\;|\\CO\quad CHOH\\|\quad\;\;|\\NH—CO\\\text{(Dialuric Acid.)}\end{array} + 2H_2O$$

$$\begin{array}{l}NH—CO\\|\quad\;\;|\\CO\quad CHOH\\|\quad\;\;|\\NH—CO\\\text{(Dialuric Acid.)}\end{array} + \begin{array}{c}NH_2\\ \\NH_2\\\text{(Urea.)}\end{array}\!\!>CO = \begin{array}{l}NH—CO\\|\quad\;\;|\\CO\quad C—NH\\|\quad\;\;\|\\NH—C—NH\\\text{(Uric Acid.)}\end{array}\!\!>CO + 2H_2O$$

Whether this possible synthesis is the actual one occurring in the organism of the bird is still doubtful, and although this author's experiments seem to favour the theory that a similar synthesis occurs in man, still, as he himself remarks, its importance compared to the purin origin is probably not great. In mammals there can be no doubt that the purin-holding substances constitute the main source of uric acid, and Minkowski in his most recent investigations comes to the conclusion that in dogs, at least, the synthetic mode of origin is of extremely slight importance, if it exists at all. The purin mode of origin is undoubtedly the most important one in mammals. Thus after a diet rich in nucleins (nucleo-proteids) there is a marked increase in the amount of uric acid excreted, both absolute and relative to the urea. This transformation can take place outside the organism, as for example when spleen or any tissue rich in nucleins is kept in contact with oxygenated blood at body temperature. A rise in uric acid excretion after a meal free from nucleins is probably due to an increased nuclein metabolism in the tissues (*e.g.* digestion leucocytosis).

Horbaczewski was the first to refer to endogenous sources of uric acid. He drew attention to a possible connection between increase in number of leucocytes and increased uric acid production, but his conclusion that all forms of leucocytosis are accompanied by this uric acid rise is certainly incorrect. Leucocytosis accompanies pathological conditions of the most diverse nature, so that it was scarcely reasonable to expect that their effect on metabolism would be the same. One would expect that if the rise were due to the purin derivable from the nucleins present in the leucocytes, this would be most marked when the number of leucocytes was falling. One would also expect that a rise in P_2O_5 would accompany the increased purin excretion, seeing that the former must be set free after nuclein disintegration, and this does not occur in all cases, *e.g.* leucocythæmia. That variations in the absolute number of leucocytes in the body, or more likely alterations in the metabolism of the white blood corpuscles, occurring with or apart from an absolute increase in their number, may affect the purin excretion is, however, very probable, and that the purin-holding foodstuffs do so is undoubted.

The excretion of uric acid in gout is a subject upon which opinions differ greatly, and the reader must be referred to the special article on "Gout."

The difficulties that are met with in trying to discover the significance of an alteration in the amount of uric acid excreted are intelligible when one remembers that there may be an increased *production of uric acid* with no effect on the excretion, because it may be broken up into urea in the liver, or the variations in the quantity excreted may simply be due to a more rapid or slow removal by the kidneys.

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Urination, Disorders of.

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Incontinence in Children.—In the physiological act of micturition the natural stimulus and evacuation of the bladder is a degree of mechanical distension of the organ. When this reaches a certain degree afferent impulses pass through the spinal cord and the brain, which in turn sends out efferent impulses to the bladder, bringing into play the natural muscular mechanism which effects the expulsion of urine. After the third year of life the urine may be held during sleep for eight or nine hours, and at other times for two or three hours. If a child cannot control his bladder during his waking hours by the time he has reached his third year he may be regarded as suffering from incontinence (Thomson). Incontinence may be due to—

1. Some defect in the wall of the bladder or urinary passage in any part of its course.
2. An alteration in the character of the urine, or
3. A change in the nervous mechanism which governs micturition.

Enuresis due to Defect in the Bladder or Urinary Apparatus.—This may be due to some malformation, *e.g.* a small meatus, extroversion of the bladder, epispadias, or hypospadias. Long or adherent prepuce is also a common cause, and among rarer conditions we find polypoid growths in the bladder or at the urethral orifice. Cystitis is not a common affection in children, but when present always gives rise to incontinence of urine. Included in this category also is the atonic condition of the sphincter of the bladder which may be present in any acute or chronic debilitating illness. Intestinal worms and scybalous masses in the bowel may also determine increased frequency of micturition. In intractable cases a careful visual examination of the urinary apparatus, vulva, etc. should be made.

Enuresis due to Alterations in the Character of the Urine.—In every case of incontinence of urine in children the urine should be carefully examined, special attention being paid to the degree of acidity and the presence of any abnormal constituents. Oxaluria, phosphaturia, and uric acid in excess may be the determining cause. If the presence of one or other of these is determined, attention must, of course, be directed to the diet and the state of the gastro-intestinal tract.

A Change in the Nervous Mechanism which governs Micturition.—As the controlling nervous mechanism of micturition is a complex one, we find that there are many factors which may effect a disturbance of the act. These may be roughly grouped as follows :—

1. Defects in the higher controlling centres in the brain.

2. Disease in the spinal cord (lumbar region) which involves the reflex centres for micturition.

3. Derangement of the peripheral nervous mechanism in the wall of the bladder.

Epileptics, imbecile and mentally deficient children, are on this account prone to suffer from incontinence. Fright is another factor which occasionally induces an inability to retain urine for the normal time. Any disease of the spinal cord may give rise to want of control over the bladder. This disease may primarily involve the lumbar centres, or secondarily from interference with the conducting paths in the cord. We must admit, however, that in many cases of incontinence in children no lesion can be discovered to account for the symptoms, and in such cases we are forced to take refuge in the theory of disturbed nerve action from unascertained causes. This disturbance may manifest itself either in delicate children or in those in apparently robust health. In some cases there is some inability to retain the urine during the day as well as at night. In most cases, however, the incontinence is nocturnal only. In some cases there is a history of bed-wetting from early infancy; more frequently the disease has developed after the first few years of life.

Treatment.—It will be obvious from what has gone before that the treatment must be etiological. Every attention should be paid to ascertain what part of the mechanism of micturition is at fault in any case. If the urine is obviously faulty diluents and alkalies with a change of diet may be all that is necessary. Any source of local irritation in or about the bladder, or peripheral source of irritation, *e.g.* in the intestines, should be removed. The ordinary cases, due to unascertained causes, are the most intractable. Careful attention to regular habits of micturition are essential. The medicinal remedies of most value are belladonna, ergot, and cantharidis. Belladonna is best administered in the form of the tincture, 20 to 60 minims at bedtime, according to the age of child. If this fail, ergot, in 20 minim doses twice or thrice daily, may succeed, or a cantharidis blister over the sacrum may be tried. The diet should in all cases be investigated. A purely milk diet may give a very good result in cases which resist all medicinal remedies. The application of the cold douche to the spine is a means of treatment that is much advocated by some authorities. The child before being put to bed should sit in a bath or tub, and from one to two gallons of cold water poured down the spine from the nape of the neck. It is then rubbed dry and put to bed (Carmichael).

Dysuria in Children.—Pain in micturition in children is usually dependent on one of the following causes :—

(*a*) Phimosis or preputial adhesions.

(*b*) Vulvitis.

(*c*) Uric acid or phosphates in excess in the urine.

The child has a constant desire to pass water, and screams with pain when she tries to do so. Treatment must be directed to the cause. When due to the presence of uric acid in excess the condition may be accompanied by a true renal colic.

Increased Frequency of Micturition in Adults.—This may be dependent on a defect in the bladder, a condition spoken of as irritability of the bladder. It may be due to various forms of inflammation of the bladder wall, calculi, foreign bodies, or tumour growths. Again it may be due to a stricture of the urethra. A very frequent cause in old age is enlargement of the prostate gland, more especially in cases attended with enlargement of the middle lobe. Renal disease is also a cause, more especially chronic nephritis and pyelitis. In addition to these various diseased states involving the urinary apparatus, increased frequency, often attended by some incontinence, may arise from various constitutional derangements which are attended by the passage of an abnormal urine. The most striking illustrations in this group are diabetes mellitus and insipidus, and hysteria. It is probable that some cases are to be explained by the existence of early vascular disease throughout all the organs and tissues of the body. In such cases the vaso-motor control of the circulation is defective, and variations in the calibre of the renal vessels occur with more frequency than in perfectly normal conditions, with the result that a large amount of limpid urine of low specific gravity is passed. Increased frequency of micturition varies in degrees; it may exist as a single symptom, but more usually it is accompanied by other symptoms which aid the diagnosis. The diagnosis of the cause is made from the following:—

1. From a careful examination of the history, the duration of the complaint, the age of the patient, the history of previous trouble with his urinary apparatus.
2. A digital examination per rectum, to distinguish the presence or absence of disease of the prostate gland, or any disease of the rectum which may also act as a causal agent.
3. A careful examination of the urine, more particularly noting the specific gravity, and the presence of sugar or albumin, indicating structural or functional derangement of the kidneys and other organs.
4. If the foregoing are negative, attention should be directed to a general medical examination of the patient, paying particular attention to the state of the heart, blood-vessels, and blood pressure. Definite changes may then be found long before the urine reveals the presence of any abnormal constituent.

The treatment will, if necessary, vary with the cause. The only point calling for further note is number four. The line of treatment should be, (*a*) judicious use of aperients; (*b*) attention to the functions of the skin, *e.g.* by the use of Turkish baths and the like; and (*c*) medicinal remedies, more especially iodide of potassium in small doses.

INCONTINENCE AND OVERFLOW OF URINE IN THE ADULT.—A true inability to retain water on the part of the bladder is a very rare occurrence, and is chiefly found in cases of disease of the nervous system, and is then usually accompanied by indications of paralysis in other parts of the body. The increased frequency of micturition in people over sixty years of age or thereby, which involves passing water every hour or two both by day and night, is not really incontinence, but the reverse. The defect in these cases is an inability on the part of the bladder to empty itself, the cause being usually obstruction from an enlargement of the prostate gland with secondary weakness in the wall of the bladder. There are three methods of treatment applicable, depending on the stage and severity of this disease. These are—

1. In the early stages educate the patient not to cease the attempts at micturition until every drop of water has been passed that can possibly be done by a sustained effort. This is a most important therapeutic point, and if early attended to much benefit will be derived.

2. The use of a soft or flexible catheter used under the strictest aseptic precautions.

3. Operative measures directed to the removal of the prostate gland, or that part of it which is the cause of the mechanical obstruction. This subject is further considered in the section on "Prostate Gland." In these cases the muscular tone of the bladder wall may sometimes be improved by the use of general and nervine tonics, or by electricity, or various massage treatment carried out by an expert in the Turkish system of massage (see "THERAPEUTICS, *Treatment by Physical Methods*," vol. xii.)

Incontinence from Disease of the Nervous System.—This is an important group of cases, of which typical illustrations are tabes dorsalis, general paralysis, and indeed all chronic diseases approaching their natural termination. Having regard to the nervo-muscular mechanism involved in the act of micturition we can readily understand that a defect may be due to—

(*a*) A lesion in the brain cortex, accompanied by dulling of the sensibility (paralysis of sensation), or inability to give rise to adequate efferent stimuli (motor paralysis). This factor is perhaps the most important one in explaining incontinence of urine towards the end of any chronic exhausting disease.

(*b*) A defect in the conducting columns of the cord, such as is present in cases of tabes and other chronic diseases of the cord.

(*c*) Interference with the normal activity of the sphincter centre and micturition centre in the lumbar region of the cord, *e.g.* in cases of paraplegia, traumatic or otherwise, and also in tabes, etc.

The temporary nature of the bladder symptoms in some of these cases is best explained on the assumption that the nutrition of the nerve cells and fibres is from time to time interfered with, mainly from a spasm of their nutrient vessels. It is important to appreciate this point, because it indicates the necessity of treatment of these cases being conducted on general medical lines, and not on strictly neurological lines, as is frequently the case.

A word may be said as to the occurrence of disorders of urination in the adult female. The chief point that requires to be added to what has been said has reference to the gravid uterus. In the early and later months of pregnancy increased frequency of micturition may be a prominent symptom. If the symptoms become prominent we should suspect a complication, *e.g.* retroflexion of the gravid uterus, or other complications, such as a dermoid, or ovarian or uterine tumour. The position of the urethra in woman makes it more easy for pressure to induce a slight degree of irritation followed by incontinence. In these cases treatment must be directed to the causal conditions.

RETENTION OF URINE.—In the majority of instances this is dependent on mechanical obstruction, the most common causes being an enlarged prostate, and a stricture of the urethra, the result of previous urethritis. An impacted calculus and tumour growth are rarer causes of retention. Retention of urine must not be confounded with suppression, the latter being the result of defective renal activity, as a result of which no urine is produced and the bladder remains empty. Mention should be made of cases of hysterical retention of urine. Young women especially are the subjects of this disorder. No urine may be passed for a few days, or even longer, and on examination the bladder may be enormously distended and contain several pints of urine. It is a wise rule in these cases not to withdraw the whole of the urine at one operation. By so doing the risk of the occurrence of bleeding from the vessels of the bladder wall, which have been suddenly relieved of their strain, is minimised. The treatment of ordinary cases of retention is the treatment of the disease causing it. A catheter of appropriate size and kind should be used. Among other remedies mention should be made of—(*a*) the use of a hip bath at a temperature of 100° to 110° F., (*b*) hot fomentations over the pubic region, (*c*) the use of active purgative medicines, and (*d*) the use of morphia as a temporary measure. If opium be used it should be used in full doses.

Anuria.—Absence of urination may be due to suppression, or it may mean that the ureter of a working kidney has become completely blocked, while the other kidney has from some cause been thrown out of action. The nature of the injury, or the character of the disease causing this, varies greatly. They may be classified as follows (Newman):—

1. Reflex inhibition of the functions of the opposite healthy kidney.
2. Impaction of a stone at a previous date, followed by hydronephrosis or atrophy of the kidney on the opposite side to the one recently attacked.
3. Other unilateral disease of the kidney, such as tuberculous nephritis, pyonephrosis, or congenital absence of one kidney.
4. Bilateral disease of the kidneys, including the various forms of Bright's disease, cystic degeneration, etc.

The diagnosis of these conditions is established from—(*a*) the history of the case, (*b*) careful bimanual examination of the region of the kidneys, and (*c*) the presence of uræmic or other symptoms indicating a severe toxic poisoning.

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I. Introductory

Examination of the urine is one of the most ancient of methods employed in the diagnosis of disease, and advancing knowledge, far from diminishing, has greatly enhanced the value of the indications which it affords.

Whereas the early physicians, from Hippocrates downwards, were perforce content with what could be learnt by such simple means as inspection and smell, in more recent times analytical methods, both qualitative and quantitative, have been applied to the recognition and estimation of the various constituents of this highly complex mixture, and the microscope, spectroscope, and polarimeter, not to mention other instruments, are all brought into requisition for the elucidation of certain special points.

By such means a great mass of knowledge has been accumulated regarding the composition of the urine in health and the changes which it undergoes in disease, but it will only be possible to speak, within the limits of the present article, of such points as are of special importance and interest from a clinical rather than a pathological standpoint, and to describe briefly such simple methods of analysis as are employed in clinical work. For discussions of the more complex problems which arise, as also for the more elaborate methods in use in the laboratory, it will be necessary to refer the reader to the various treatises devoted to the subject.

So many of the waste products of metabolism are chiefly or wholly eliminated in the urine, that the changes in the amounts of its various constituents, and the presence in it of substances which are not present under normal conditions, afford very important indications of disturbances of the complex chemical processes at work in the organism.

The individual constituents are derived from various distinct sources. Some of them are products of the metabolism of the tissues of the body itself, waste products of the combustion of the muscular, fatty and other structures. Others, again, are substances introduced into the alimentary canal, and which, although they are thence absorbed, are not incorporated into the tissues but find their way either unchanged or in altered forms into the renal excretion. These two classes of substances overlap to a considerable extent, and not a few of the constituents of the urine are partly endogenous, *i.e.* products of tissue metabolism, and partly exogenous, that is to say, constituents of the food which pass through the body unchanged. Some of these latter, as for example certain inorganic salts and many drugs, fulfil highly useful purposes in their passage.

In yet another class may be included certain products of the action of the bacteria which are so abundantly present in the alimentary canal, either upon the materials of the food or upon the constituents of the bile, and the quantities of such products excreted in the urine afford valuable information as to the state of affairs within the alimentary canal. Among such derivatives of the food may be classed the members of the indoxyl group, which are excreted by the kidneys in the forms of indoxyl sulphates and glycuronates, and other aromatic compounds which also appear as conjugated sulphates. On the other hand urobilin, the chief member of the latter group, has for its parent substance the pigment of the bile.

Among the products of the body tissues which appear in the urine in disease are some which do not appear to be formed in the normal organism, and others which must be looked upon as intermediate products of metabolism which, in consequence of the abnormal conditions which prevail, have escaped the further changes which they normally undergo, and are therefore excreted as such. However, it is not yet possible to make any complete classification of the urinary constituents according to their places of origin, since we are still in ignorance of the sources and modes of formation of not a few of them.

Of no less clinical importance than the evidences of disordered metabolism which are obtained from the study of the renal excretion are the indications which are afforded of disease in the urinary tract. Thus the power of the kidneys to hold back the albumin and globulin of the serum is easily impaired by morbid changes in those organs, with the result that these proteids are excreted in the urine in larger or smaller amounts. It is in this connection, too, that the microscope is of special service in urinary diagnosis, for, with the exception of some kinds of bacteria, all organised cells or groups of cells present in the urine have their origin in the kidneys, ureters, or some other portion of the genito-urinary tract, or in cavities in communication therewith. Thus by means of the microscope we are able to distinguish between hæmaturia due to hæmorrhage from the kidneys or from below them, and hæmoglobinuria resulting from the presence of free blood pigment in the plasma. Again, epithelial cells of various kinds are met with, from the shapes and sizes of which it is often possible for the trained eye to recognise the portion of the genito-urinary apparatus from which they are derived.

Bacteria of various kinds are met with in the urine either as the result of infection of the urinary tract from without, or of diseases of the kidneys and passages, or, as appears to be the case in typhoid fever and some other infective diseases, of their expulsion from the body by way of the kidneys. In the former case the presence of bacteria is usually associated with evidences of cystitis or other local inflammatory processes, whereas bacteriuria of the latter kind may be attended by no signs of cystitis or pyelitis. Even here the large numbers of bacteria present probably result from their multiplication in the urine itself, only a small proportion of those expelled having actually passed the renal barrier.

One of the most remarkable features of the urine is the manner in which its many constituents are all held in solution, and do not mutually precipitate each other, a condition of affairs which is essential to the perfect performance of the functions of the human urinary apparatus. However, very slight deviations from the normal conditions suffice to interfere with the solution of some of its constituents, as is well exemplified by the so frequent deposition of uratic sediments when the urine cools to the temperature of the air, and the effect of increased or diminished acidity in favouring the deposition of crystalline uric acid on the one hand and of earthy phosphates on the other.

Hence it is by no means uncommon to meet with some or other of the constituents in the form of sediments, either crystalline or amorphous, which sediments may have been formed either before or after the liquid has left the bladder.

Under certain circumstances small concretions are formed in the kidneys, which may either remain in the renal pelvis, or pass along the ureters to the bladder. Either in the pelvis of the kidney or in the bladder they may increase in size by the deposition upon them of successive layers of the original or of some other material; and by their presence, or in their transit from place to place, they give rise to the familiar symptoms and morbid changes which are associated with calculous disorders.

Some accidental constituents derived from foods or drugs produce conspicuous effects upon the urine with which it is important to be familiar, if only that their want of importance may be recognised. In this connection certain colouring matters, such as methylene-blue, may be referred to. The coloration produced by methylene-blue has recently been utilised for the determination of the integrity of the kidneys, by measuring the time which elapses between the injection of a given quantity of the pigment and the appearance of a green tint in the urine. Again the detection of certain drugs may be of service in ascertaining whether a patient has been taking the medicines in question.

II. General Properties of the Urine

A necessary preliminary to any examination of the urine for clinical purposes is to take note of certain of its general properties—such as its colour, whether it be clear or turbid, whether it has any striking or peculiar odour, its reaction to litmus paper, and its specific gravity, which last, when taken in conjunction with the amount of the daily excretion, affords a rough indication of the quantity of solids which it contains.

Quantity.—The collection and measurement of the total urine passed in the course of the day of twenty-four hours is not only important on account of the variations in quantity observed, but is always desirable in order that from the collected total a fair sample specimen may be obtained, and is essential when any quantitative estimations of its constituents are to be carried out.

The average amount of urine passed by a healthy adult in twenty-four hours is taken as being from 1500 to 1700 cubic centimetres, or about 2½ to 3 pints. Thomas states that an adult man excretes about 1 c.c. hourly for each kilogramme of body weight. Women excrete somewhat less urine than men, and children pass considerably smaller quantities than adults.

The quantity varies at different periods of the day, being least during the hours of sleep, and greatest after the chief meal or after the free drinking of liquids. Active exertion, by increasing the activity of the sudoriferous glands, tends to notably diminish the output of urine. Apart from any obvious modifying conditions, the quantities habitually passed by different healthy individuals differ somewhat widely, and one occasionally meets with persons who, without any obvious departure from the standard of health, habitually excrete quantities considerably below those usually regarded as normal.

C. E. Simon draws an interesting comparison between the estimates arrived at from observations on normal persons in different countries, which reveal differences which he ascribes in part to habits of life and in part to climatic influences.

Nervous influences also modify the urinary excretion. Emotions such as fear or anxiety are apt to lead to an increased output, and the same may be observed in cases of hysteria, although hysterical patients occasionally exhibit actual anuria which may persist for some time.

In fevers the excretion of urine is usually diminished, partly, no doubt, as a result of cardiac weakness and consequent impaired circulation in the kidneys. During convalescence, on the other hand, polyuria is often observed. In acute nephritis the urine is scanty and actual suppression may occur, but in chronic interstitial nephritis the output is usually markedly increased, and the same is often observed in the later stages of chronic parenchymatous affections and in many cases of lardaceous disease of the kidneys.

The influence of ascites in diminishing the flow of urine, and in so establishing a vicious circle, is well recognised, and this influence is probably due to pressure upon the abdominal vessels and a resulting diminution of the flow of blood through the kidneys.

As is only to be expected, when large quantities of water are being lost by the bowels in diseases attended by diarrhœa the quantity of urine shows a conspicuous diminution, and actual suppression of urine may result from obstruction of the ureters, as in cases in which one kidney has been previously rendered useless and the ureter of the only active kidney becomes blocked by a calculus.

Polyuria is a conspicuous symptom of *diabetes mellitus,* and far larger quantities still are passed in the remarkable cases which are grouped together under the name of *diabetes insipidus.* In not a few nervous diseases polyuria may occur, and whereas in hysteria and under the influence of emotions the excess is usually transitory, when the nerve centres are the seats of organic disease it tends to have a more permanent character.

In conclusion, mention must be made of the intermittent passage of large quantities of urine as a valuable diagnostic sign in cases of advanced unilateral hydronephrosis with intermittent emptying of the sac.

Specific Gravity.—As so often carried out with isolated specimens of urine the determination of the specific gravity loses much of its value. Much more useful results are obtained when a specimen is taken from the collected urine of twenty-four hours, and more useful ones still when the specific gravity is calculated for an average daily excretion of 1500 c.c.

Low specific gravity may be due to excessive excretion of water, the total solids being normal in amount, but when the quantity is not increased it indicates a diminished output of solid ingredients. Similarly an unusually high specific gravity may indicate diminished water or an excessive excretion of solids.

In health this factor varies considerably at different periods of the day, to a great extent inversely to the quantity of urine passed.

The mean specific gravity of the urine of healthy adults is about 1020. Under abnormal conditions it may fall as low as 1002, or may rise above 1040.

For clinical purposes the specific gravity of urine is determined by means of the urinometer, an instrument too familiar to call for description. The urine to be tested should be allowed to cool to the temperature of the air, and should be gently poured, so that frothing is avoided, into a clean cylindrical vessel of considerably greater diameter than that of the urinometer. The instrument is then allowed to sink slowly into the liquid, and after it has come to rest it should be slightly depressed and allowed to float up again. The reading should then be taken from the lower meniscus.

As a rule polyuria is attended by diminution of specific gravity, but to this rule *diabetes mellitus* offers a conspicuous exception, and the association of excessive excretion with high specific gravity, 1030-1040, in itself affords strong evidence of the presence of sugar. On the other hand, it must not be forgotten that sugar may be present in a urine the specific gravity of which is not above the normal, and the routine testing for sugar should not be omitted on that account.

In *diabetes insipidus* the specific gravity of the urine may be but little above that of pure water, and in some cases of chronic interstitial nephritis also very low readings are obtained. The concentrated and highly albuminous urines of patients with acute nephritis have, on the contrary, a high specific gravity, and the administration of certain drugs which are excreted in the urine also has an elevating effect.

In the latest stages of chronic diseases, when metabolism is at a low ebb, the urine passed is often scanty in amount and at the same time of low specific gravity, owing to the scantiness of the solid constituents.

Freezing-Point; Cryoscopy of Urine.—The property of urine most recently utilised for clinical purposes is the freezing-point, and as the alterations in the freezing-point under morbid conditions have been widely studied, since attention was first called to them by A. von Koranyi in 1887-88, it will be well to give some description of the apparatus devised by Beckmann which is employed in such determinations.

The liquid to be tested is placed in a large test-tube, which can be closed by a cork with two bores. Through one bore is introduced a special thermometer of great delicacy, graduated to hundredths of a degree between + 1 and − 4° C. Through the other orifice is introduced a metallic stirrer, by means of which the liquid around the thermometer is kept in constant motion during the determination. The tube is enclosed in a somewhat larger one which acts as an air-jacket and insures equal cooling of the liquid contained in the inner tube. Both tubes are then placed in a vessel containing water which has been cooled to some five or six degrees below 0° C. by the addition of sodium nitrate or some other salt which produces a low temperature by its solution.

The first effect is a lowering of the temperature of the liquid in the inner tube below its true freezing-point. Then follows a rise, and when this rise has reached its limit the reading of the thermometer gives the true freezing-point of the solution.

The determination of the freezing-point of a solution supplies a measure of its osmotic pressure, which again is proportional to the number of molecules of the substance in solution in a unit volume of the solvent. Thus equi-molecular solutions of different indifferent substances lower the freezing-point to equal extents, and when two such substances are in solution together, the lowering of the freezing-point which results is equal to the sum of the depressions which the two substances would individually produce.

In the case of acids, bases and salts, the lowering of the freezing-point is markedly in excess of that which corresponds to the number of molecules present, an anomaly which is explained by supposing that in solution they are dissociated into their component ions, which must be supposed to produce the effect of independent molecules.

Thus the depression of the freezing-point of the urine below 0° C. corresponds to the total number of dissolved molecules or ions, and when the excretion of twenty-four hours is measured, affords an index of the total number of molecules or ions of all kinds passed in that period. The most abundant constituents will naturally be responsible for most of the effect, and these are sodium chloride and urea.

Von Koranyi attaches much importance to the ratio between the lowering of the freezing-point and the excretion of sodium chloride, and believes that a disturbance of their relation affords a very valuable indication of backward pressure in the kidneys in cases of cardiac disease.

He found that the normal freezing-point of the blood was − 0·56° C., whereas the normal freezing-point of the urine of twenty-four hours was between − 1·3°-2·2°. The variations of the ratio of freezing-point to sodium chloride excretion in twenty-four hours was much less conspicuous under normal conditions, viz. from 1·23-1·69.

In cases of renal disease the molecular excretion may be considerably diminished, indicating a failure in the renal functions, and this deficiency may reach such a point that the freezing-point of the urine may actually be higher than that of the blood of the same patient. Thus Lindemann, who found the normal freezing-point of the urine to vary between − 1·30° and − 2·30° C., states that in inflammatory diseases of the kidneys, in which average quantities were passed in the twenty-four hours, the depression of the freezing-point is usually less than one degree.

Lindemann also found that in interstitial nephritis the phenomenon is much less marked than in the parenchymatous variety, and again that in acute nephritis the progressive depression of the freezing-point of the urine until ultimately normal figures were reached afforded a valuable index of the process of repair in the kidneys.

It will not be desirable in the present state of our knowledge to enter here upon any detailed consideration of the somewhat complicated questions which arise in connection with this method of urinary investigation, which is as yet in its infancy, nor to discuss the theories upon which von Koranyi explains the results which he has obtained in cases of cardiac disease with secondary disturbances in the kidneys. These will be found set forth at length in his original papers, and an interesting summary of them, in our own language, was given by Huddleston in the *Philadelphia Medical Journal* in 1900.

The most valuable results are obtained by the comparison of the freezing-points of the blood and urine respectively, and also by comparing the urine obtained from each kidney separately by catheterisation of the ureters.

Reaction.—The acid reaction of normal urine is not due to the presence of a free acid, but to acid salts of which the mono-sodium phosphate is the most important. The degree of acidity is to a large extent determined by the relative amounts of mono- and di-sodium phosphates present, and when a certain proportion is reached the urine will have an amphoteric reaction, that is to say, will redden blue litmus, and render red litmus blue. This is the condition with what are known as neutral urines, but which are not neutral in the strict sense of the term.

The reaction of the urine varies at different periods of the day, and the excretion of alkaline urine, rendered turbid by precipitation of earthy phosphates, during the morning hours is not uncommon, even with healthy persons. Diminished acidity is also observed an hour or two after a meal.

A diet rich in meat tends to increase the acidity of the urine, whereas a vegetable diet has a contrary effect, and the urine of vegetivorous animals is habitually alkaline. The administration of mineral acids raises the acidity of the urine to some extent, and alkalies have a still more conspicuous effect in lowering acidity, or if taken in sufficient quantities, of rendering the urine alkaline. The sodium and potassium salts of such organic acids as citric and tartaric, which become converted into carbonates in the body, also diminish the acidity of the urine.

Absorption of alkaline exudates and transudates is accompanied by diminished acidity or even alkalinity of the urine, and conversely the formation of such effusions, with a corresponding withdrawal of alkalies from the blood, tends to render the urine more acid.

Concentrated urine, such as that passed during fevers, is usually abnormally acid, and a high degree of acidity favours the deposition of urates and the separation of crystalline uric acid, but the excretion of alkaline urine is of more importance from a clinical point of view.

Alkalinity may either be due to the presence of an excess of fixed alkali or to the formation of ammonium carbonate from the decomposition of urea. The passage of urine which is alkaline from fixed alkali has no clinical importance, unless the effect of the administration of alkaline hydrates, carbonates or salts of vegetable acids, can be excluded. Apart from such causes, the persistent excretion of alkaline urine may have its origin in anæmic conditions, malnutrition and other debilitated states, and especially those in which the nervous system is affected. This symptom is usually removed by tonic treatment rather than by the administration of mineral acids. On account of the precipitation of the earthy phosphates this condition is often inaccurately spoken of as phosphaturia. Ammoniacal urine, which may be recognised by the blueing of moistened red litmus paper held above the surface of the liquid as well as by its odour, is only of clinical importance when it is passed as such. It then indicates infection of the urinary tract and decomposition occurring in the bladder or elsewhere. Such urines are usually rich in mucus-like substance, and deposit crystals of triple phosphate.

Turbidity.—Normal urine is clear and transparent, but on standing it deposits a slight cloud, the so-called nubecula, which is well seen in the apex of a conical glass. Under morbid conditions the urine may be turbid when passed or it may become so on cooling, in the latter case from the separation of amorphous urates. The commonest cause of turbidity of the urine as passed is the precipitation of earthy phosphates which occurs when the liquid is rendered alkaline, and which is not infrequently observed during the alkaline tide which follows a meal or as the result of ammoniacal decomposition.

A common variety of minor turbidity results from the presence of excess of mucus-like substance; the most extreme degree of opacity results from the abundant presence of finely divided fat in the condition known as chyluria.

Odour.—The faint odour of normal urine is familiar to all and is characteristic, as also is the offensive smell of urine which is undergoing ammoniacal decomposition. When a communication exists between the bladder and bowel the urine may have a fæcal odour, and under certain conditions, which will be referred to later, it may emit sulphuretted hydrogen in quantities sufficient to be recognised by the nose. In diabetes and some other conditions the presence of acetone may impart a characteristic odour to the urine.

The effect of eating asparagus has been ascribed by Nencki to the presence of methyl-mercaptan. The odour of copaiba is easily recognised, as also the smell of violets given off by the urine of patients taking turpentine.

Colour.—The normal yellow colour of urine is apt to be greatly modified under many morbid conditions. Such changes are in part due to alterations in the relative amounts of what may be called the true urinary pigments viz., urochrome, urobilin, uroerythrin and hæmatopophyrin, all of which may be present, at least in traces, in the urine of healthy individuals, and in part to the presence of other colouring matters which are not normally present in the urine.

The presence of abundance of urobilin imparts a rich orange colour and very large quantities may give a brown tint. Uroerythrin gives a redder orange colour, such as is so often exhibited by the urine of patients with febrile disorders or with organic diseases of the liver. A peculiar orange colour is seen when bilirubin is present in small amount, but, owing to the admixture of biliverdin, urine containing bile often has a greenish-brown tint.

The administration of santonin or of chrysophanic acid, which is contained in rhubarb and senna, causes an intensification of the yellow colour, which is changed to pink by the addition of alkalies.

Dark brown urines are not uncommon. The commonest causes of this colour are the admixture of bile-pigments, or of blood-pigment in the form of methæmoglobin. Urines rich in indican, which is itself colourless, often have a dark brown colour which is ascribed to higher oxidation products of indol.

In carboluria the urine has a brown colour with a tinge of green, due to the oxidation of hydroquinone, and a similar aromatic oxidation product causes the dark brown colour seen in the rare condition known as alkaptonuria. In melanuria the urine as it darkens passes through a brown stage, and mention must be made of the brown colour of the urine in some cases of pernicious anæmia, which is usually ascribed to urobilin, but is probably not entirely due to the abundance of that pigment present.

Pink or red urines most commonly owe their tint to an admixture of blood or of free oxyhæmoglobin. A port wine tint is usually exhibited in hæmatoporphyrinuria, and rosaniline and some other aniline derivatives given as drugs or contained in sweets may impart a pink colour to the urine. Special mention should be made of the eosin-like pigment which is sometimes present in sweetmeats, which renders the urine pink with a bright green fluorescence.

Black urines are usually extreme examples of one of the above anomalies. In melanuria, alkaptonuria, and in extreme cases of carboluria the urine becomes black in time, and in some cases of hæmatoporphyrinuria blackness is produced by other less known dark pigments which are usually present with hæmatoporphyrin in such cases.

Urines rich in biliverdin may have a rich green colour, but green and blue urines usually owe their tint to smaller or larger quantities of methylene-blue, which is sometimes given as a drug and is sometimes contained in sweetmeats.

Suspended indigo may produce a blue scum upon the surface of an alkaline urine, and occasionally imparts a bluish tint to the whole.

Very scanty pigmentation may be due to a deficiency of urochrome, and the urine of young infants is often almost colourless. A similar want of colour may be due to dilution, as in all kinds of polyuria, and especially in *diabetes insipidus* in which dilution reaches its most extreme degree.

Toxicity.—When urine is injected into the circulation of animals it causes their death, but different species of animals differ in the ease with which they succumb to such poisoning. Bouchard found that 45 c.c. of normal human urine per kilo of body weight was fatal to rabbits. The nature of the constituent or constituents which produce this effect has been much discussed, and is still to some extent an open question. The only point clearly established is that the toxic properties reside, in the main, in the inorganic constituents, and that of these the potassium salts are at any rate the most potent in this respect. The various organic constituents, such as urea, uric acid, kreatinine and pigments have been shown one by one to be incapable of producing the effect, at least in such amounts as are present in the quantities of urine experimented with, but it is held by some that although the toxicity is mainly due to potassium, other constituents contribute to the fatal results. Herringham in a recent research found a close correspondence to exist between the toxicity of the urine and the amounts of potassium contained in it, and similar results had previously been obtained by other observers. Charrin and Roger, on the other hand, failed to trace such a correspondence. The toxic symptoms are, moreover, such as result from poisoning with salts of potassium.

III. The Inorganic Constituents of Urine

It will be convenient to commence the review of the several constituents of the urine in their clinical bearings with the consideration of the simplest of all, viz., the inorganic constituents, in which group may be included hydrochloric, sulphuric and phosphoric acids, and the metals sodium, potassium, calcium, magnesium, and iron.

The quantities of these which are contained in the urine are subject to considerable fluctuations under different conditions, and in the case of most of them the influence of diet is so great that it is necessary to take this into account before drawing any conclusion as to the influence of morbid conditions upon their excretion. To arrive at any valid results it is therefore important to know the amount of the particular acid or base that is being studied in the ingesta as well as in the egesta both liquid and solid.

The Chlorides.—The great bulk of the chlorine excreted in the urine is in the form of sodium chloride, and only a small proportion is combined with other bases. Even under normal conditions the daily excretion varies somewhat widely, but quantities corresponding to 10-15 grammes of sodium chloride may be taken as the normal average.

The chief factor which determines the variations observed in health is the quantity of sodium chloride taken in and with the food. On a diet poor in salt, or during a period of fasting, the output is conspicuously diminished, whereas when the food is rich in salt the reverse is the case. During the day the quantity excreted in the urine is greater than during the night, and this even in spite of a meal rich in salt taken late in the day.

The drinking of large quantities of water increases the excretion, and a similar increase results from a diet rich in potassium salts or from the administration of such salts as drugs. This increase Bunge ascribes to the combination of some of the chlorine of the sodium chloride of the blood with potassium, and the elimination of the potassium chloride so formed as of a foreign substance.

In chronic diseases the chloride excretion varies, as a rule, with the nature and quantity of the food taken. Von Noorden has observed diminished excretion after copious hæmorrhages, which he attributes to the loss with the blood and the retention of the amount of sodium chloride required for the supply of the new plasma which replaces that which has been lost. The variations observed in other forms of anæmia may be attributed to diet, and in pernicious anæmia to the condition of inanition which supervenes.

In connection with the excretion of chlorides in gastric diseases it must be remembered that several factors may contribute to influence the output, such as the quantity and quality of the food taken, the amount of hydrochloric acid in the gastric juice which may be lost by vomiting, and the interference with absorption which may result from pyloric obstruction. Von Noorden calls attention to the importance of the relation between the excretion of chlorides and that of urea in diseases of the stomach. A simultaneous diminution of both points to simple inanition, whereas scanty chlorides with abundant urea point to breaking down of the proteid tissues, which are poor in sodium chloride, and such a breaking down occurs in the cachexia which results from malignant growths.

In renal diseases, such as acute and chronic nephritis, the chlorides are excreted in diminished quantity, as also are the other inorganic salts.

Of peculiar interest is the influence of fevers, and especially of acute pneumonia, upon the output of chlorides in the urine. Redtenbacher, in 1850, emphasised the remarkable diminution of the urinary chlorides in acute pneumonia, and since then his observation has been abundantly confirmed by a number of observers. Among these Lionel Beale, Fränkel, Röhmann, Terray, von Moraczewski, and R. Hutchison may be mentioned, and it is upon Hutchison's observations that the following account is chiefly based:—

The diminution, even amounting to complete disappearance of the urinary chlorides, is by no means confined to pneumonia, but is met with in other acute fevers. In fevers of long duration, such as typhoid, it is only met with during the earlier days of the attack. In malaria, on the other hand, the excretion of chloride is increased instead of being diminished. In pneumonia the diminution persists for a day or two after the crisis, and is sometimes followed by an excretion of more than the normal amounts, quantities considerably in excess of the intake with the food.

Hutchison could trace no relation to the height of the fever nor to the extent to which the lungs were involved in different cases, and whilst the chlorides undergo such marked fluctuations nothing comparable occurs with the other inorganic salts, the phosphates and sulphates.

A comparison of the intake and output shows that the diminished excretion is due to an actual retention of chlorides, for it can be shown that the absorption from the alimentary canal is not impaired and that no adequate vicarious excretion occurs by the skin or other channels.

The total excretion in the sputum is small, although the sputum is rich in sodium chloride. The inflammatory exudate, on the other hand, is not very rich in chloride, and the quantity contained in it will not account for the retention as was formerly supposed. Nor can the retention be ascribed to lesions of the kidneys, for nothing comparable is seen even in acute nephritis which causes a diminution of the other inorganic salts of urine also.

Hutchison, whilst he was unable to obtain evidence of the accumulation of chlorides in any special organ in cases of pneumonia, found that the fixed tissues as a whole were apparently somewhat richer in these salts than usual. He brings forward evidence against the view that the retention of chlorides is merely secondary to that of water, and that it simply represents the quantity required to form with the retained water a saline solution of the normal concentration. In the estimation of the urinary chlorides advantage is taken of the well-known precipitation as chloride of silver, and several volumetric methods have been devised for this purpose which will be found described in works on urinary analysis.

Sulphates.—The normal daily output of sulphates in the urine corresponds to some 1·5-3 grammes SO_3. Of the sulphates the greater part occur as simple metallic salts, whereas a far smaller portion is in combination with aromatic substances, as ethereal or aromatic sulphates, of which the indoxyl-sulphate, the so-called urinary indican, affords the most familiar example. Not all the sulphur contained in urine is in the form of sulphates, some always appearing as neutral or unoxidised sulphur.

Of the total sulphates some portion is derived from the food, but the bulk is a product of the breaking down of the tissue proteids, some of which are much richer in sulphur than others. Sulphates administered as drugs appear for the most part as such in the urine.

No such clinical interest attaches to the variations in the total sulphates of the urine as to those in the chlorides. As may be inferred from their proteid origin, they tend to vary concurrently with the nitrogen excretion, the relation of the total nitrogen to the total H_2SO_4 being about as five to one. Accordingly, an increased excretion accompanies febrile disorders and results from active muscular exertion, and, as Garratt has shown, occurs at an early period of such exertion. An increased output has also been observed in leukæmia.

Of far greater clinical importance is the proportion of ethereal to simple sulphates, as affording evidence of the amount of proteid decomposition in the alimentary canal, but of this it will be necessary to speak later in connection with the excretion of aromatic substances.

Phosphates.—Of the phosphates of urine the major portion is derived from the food, the minor from tissue metabolism. The phosphoric acid is combined with several bases, partly as mon-acid and partly as di-acid phosphates. The total excretion amounts to some 2·5-3 grammes P_2O_5 in the twenty-four hours, but varies considerably with the nature of the diet taken.

The phosphates of the alkali metals, especially of sodium, exceed in quantity the phosphates of calcium and magnesium or earthy phosphates.

A diet rich in alkaline phosphates markedly increases the urinary output, whereas the phosphates of calcium and magnesium are to a large extent excreted by the intestine. An animal diet causes a greater excretion than a vegetable one, and the urine of vegetivorous animals is notoriously poor in phosphates. A very small portion, a few milligrammes daily, of the phosphoric excretion is in the form of glycero-phosphates.

In such renal diseases as acute and chronic parenchymatous nephritis the output of phosphates is often markedly diminished.

In studying the variations in the excretion of that portion of the total phosphates which is endogenous, and derived from the metabolism of substances rich in phosphorus, such as nucleo-proteids and lecithin, it is important to exclude the greater fluctuations which result from differences in diet, and the evidence which is forthcoming upon this matter is not of very great clinical importance. In fevers there is a like diminution as compared with the output of nitrogen, although the total excretion may be above normal.

In bone diseases, such as rickets and osteomalachia, we might expect to find a conspicuously increased excretion of phosphates, but no such distinct effect is observed. However, in this connection it must be borne in mind that the intestine appears to be the main channel of the excretion of calcium phosphate, and it may be that to this is due the absence of any noticeably increased output in the urine.

Many observations have been made as to the phosphate excretion in cases of central nervous diseases, which affect structures rich in lecithin and might be expected to exert a distinct influence, but the results have not been striking or uniform in character.

In *diabetes mellitus* there is usually a markedly increased excretion of phosphates and a condition which has been called phosphatic diabetes is described in which, in association with the symptoms of diabetes, there is an excretion of large quantities of urine rich in phosphates.

Much importance has been attached by Zülzer, whose views are supported by the investigations of Edlefsen, to the relative excretion of phosphoric acid and of nitrogen, as affording evidence of the share taken by the different tissues in the metabolic processes in any given case, a relatively large excretion of phosphoric acid pointing to the breaking down of those tissues which are rich in phosphorus, in other words in nucleo-proteids and lecithin.

The name "phosphaturia" is often loosely applied to the spontaneous deposition of earthy phosphates in the urine, a condition which affords no indication whatever of the amount of phosphate excreted but is merely the result of a lowered acidity.

The passage of amphoteric or alkaline urine may be due to the presence of an excess of alkaline salts in the blood, either as a result of their administration by the mouth or as a pathological condition, or to the ammoniacal decomposition of the urine in the bladder or elsewhere. It is upon such causes, and not upon excessive secretion, that the deposition of earthy phosphates upon urinary calculi depends.

The estimation of the phosphates in urine is carried out by titration with a standard solution of a uranium salt, after the addition of acetic acid and sodium acetate.

Metals.—Under normal conditions, and upon an ordinary mixed diet, the salts of sodium are in excess of those of potassium in the proportion of about 5-3. The abundant presence of sodium salts in the food is largely responsible for this excess. A conspicuous diminution of the sodium excretion is observed in fevers, which diminution is chiefly referable to the retention of sodium chloride under such conditions. The administration of salts of potassium is productive of an increased excretion of sodium, and Bunge's explanation of this fact has been already referred to in the section relating to chlorides.

The variations in the excretion of calcium and magnesium have not as yet acquired any special clinical interest. The fact that the intestine is the main channel of their excretion deprives the results of urinary analyses of much of their importance, and perhaps explains to some extent the indefinite results of such analyses in rickets and osteomalachia. A markedly diminished excretion of calcium has been observed in the course of pregnancy.

Traces of iron are normally present in the urine, but the form in which it occurs is at present unknown. It is probably excreted as an organic compound. Whatever its nature, the iron-containing constituent is thrown down with the crystals of uric acid, in which the presence of this metal can readily be demonstrated, and more abundantly in those spontaneously formed than in those precipitated by the addition of acids.

Ammonium.—Seeing that ammonia is readily formed by the decomposition of urea, it is necessary that any observations on the quantity of ammonium salts in urine should be carried out upon quite fresh specimens. The total ammonia excreted by a healthy adult is some 0·7 gramme in the twenty-four hours. Some of this is derived from the food, drink, and even from the air inspired, but the greater part is a product of proteid metabolism. The administration of mineral acids to man and to flesh-eating animals increases the output of ammonia, which instead of undergoing a further change to urea serves to neutralise the free acid introduced, and so the loss of fixed alkalies, which would otherwise result, is avoided. With vegetivorous animals this is not the case, for some reason not clearly understood, and the acid introduced is by them excreted in combination with potassium and sodium.

The excretion of ammonia is increased in fevers, and conspicuously so in *diabetes mellitus* under certain conditions. This increase, which may amount to as much as four to six grammes in the twenty-four hours, cannot be ascribed in any but small part to the diet rich in proteids which is usually taken by such patients, and is apparently due to the formation of aceto-acetic and β oxybutyric acids, which are neutralised by ammonia, just as are mineral acids given by the mouth.

Such greatly increased output of ammonia is apt to precede the onset of diabetic coma. The clinical significance of the increased output of ammonia is, therefore, very similar to that of the iron reaction in diabetic cases, and it has been urged that an estimation of its amount supplies a valuable guide as to the advisability of undertaking any operative procedure in such cases.

Stadelmann recommends that when the excretion of ammonia is in excess alkalies should be administered in sufficient quantities to neutralise the abnormal acids formed.

The estimation of ammonia in urine is effected by the simple method of Schlösing. To a known quantity of the urine lime is added, and the containing vessel is allowed to stand in a closed chamber, such as an exsiccator, over a measured quantity of a decinormal solution of sulphuric acid, which absorbs, and is partly neutralised by, the ammonia given off. The amount so neutralised is estimated by titration with a standard alkaline solution.

IV. Oxaluria

Calcium oxalate is a constant constituent of human urine, and it seems clearly established that part of the amount present is a product of tissue metabolism, whereas a larger part is directly derived from the food introduced into the alimentary canal.

Of recent years many observers have occupied themselves with the study of this subject, and the researches of Salkowski and his pupils call for special mention, and in this country the work of Dunlop. Such investigations have been greatly impeded by the tedious and unsatisfactory methods formerly in use for the estimation of oxalic acid in urine, and the most recent researches gain in importance from the employment in them of a new and improved method of estimation devised by Salkowski.

The evidence for the endogenous origin of part of the oxalic acid in urine is in part derived from observations upon fasting dogs, and in part from the investigations of Lütje and Lommel upon the urine of human beings taking an oxalate-free diet, such as milk, for considerable periods. It has been shown that carbohydrates and proteids are not the sources of the endogenous oxalic acid, but, on the other hand, that in all probability gelatin is its chief parent substance, whilst kreatin and glycocol are also entitled to be included among the materials from which it is formed.

That the excretion of oxalic acid is influenced by the oxalates contained in the food, *i.e.* the existence of an alimentary oxaluria, has been questioned by some, but it has been established beyond any doubt that the vegetable constituents of the diet are its chief source. Some vegetables, such as rhubarb, spinach and tea, are specially rich in oxalic acid, and therefore have a conspicuous influence upon the excretion.

The term oxaluria is, somewhat incorrectly, applied to the deposition of calcium oxalate from the urine in crystalline form, whereas it should, strictly speaking, be limited to the excretion of oxalic acid in undue quantities. However, of the conditions which tend to produce excessive excretion, apart from dietary causes, we know little as yet, and the careful observations of Lommel and others have failed to confirm the prevalent belief that such increase is apt to occur in diabetes, and in association with jaundice. It is, therefore, with the tendency to the deposition of calcium oxalate that we are here concerned, a tendency which acquires great clinical importance from the liability which it entails to the formation of calculi in the urinary passages.

The oxalic acid of urine is in the form of the insoluble calcium salt, and among the causes which favour its deposition therefrom its excessive excretion is certainly one, seeing that the power of the urine to hold it in solution is easily overtaxed. That the urine is able to hold it in solution at all is in part due to the presence of the acid phosphates. Klemperer and Tritschler have shown that the acid phosphates of sodium, calcium, and magnesium all exert a solvent action, the sodium salt being the least, and the magnesium salt the most potent in this respect. Other magnesium salts, such as the chloride and sulphate, also favour the solution of calcium oxalate, and it would appear that a high degree of acidity of the urine and a relatively large proportion of magnesium compounds in it, are among the causes which specially tend to keep the oxalate in solution.

Dunlop found that urine which deposited crystals was usually rich in calcium oxalate, but the observations of Klemperer and Tritschler show that a continuous deposition of crystals may also occur even from urine which is poor in this substance.

The microscopical characters of deposits of calcium oxalate will be described in the section dealing with urinary sediments. Leucocytes are often present in considerable numbers in association with them, and the urine may contain albumin or even blood, as in the not very uncommon cases in which hæmaturia follows the eating of rhubarb in considerable quantities. Dull aching pain in the loins, culminating in the intense pain of renal colic, is another symptom which calls for mention.

Begbie described a group of symptoms which he regarded as characteristic of a so-called "oxalic acid diathesis," among which he included dyspepsia, hypochondriasis, neurasthenia and neuralgic pains in various situations. That such symptoms are not uncommon in association with the deposition of calcium oxalate is an undoubted fact, but there is much room for doubt whether the primary phenomenon in such cases is an increase of oxalic acid in the blood. Dunlop maintains that the symptoms enumerated are merely those of hyperacid dyspepsia, and that the increased excretion of oxalate which accompanies them is due to the solution of unusually large amounts of the calcium oxalate of the food by the unduly acid gastric juice, and a resultant increase of absorption. In spite of the advocacy of Cantani and others, the tendency at the present day is rather to attach diminished importance to the association of this group of symptoms with oxaluria.

It must be remembered that the crystals are sometimes only deposited from the urine after it has been passed, and that their presence does not necessarily imply that they were formed within the urinary passages. It is therefore important, in any given instance, to ascertain whether or no this is the case by the examination of freshly passed specimens.

Our first aim in the treatment of oxaluria must obviously be to diminish the output of calcium oxalate, as the smaller the quantity present the greater the chance of its being held in solution. With this object we should eliminate from the diet those vegetable foods which are specially rich in oxalic acid, such as rhubarb, spinach and tea. It will also be well to avoid gelatin, the taking of which has been clearly shown to increase the output. If Dunlop's views are correct, the administration of hydrochloric acid after food, which has frequently been recommended, will rather tend to do harm by increasing the absorption of oxalate from the gastric contents.

Klemperer and Tritschler recommend the taking of articles of diet rich in magnesium, such as rice, peas, farinaceous food, and coffee, and also advise the daily administration of small doses of magnesium sulphate, with a view to increasing the magnesium of the urine as compared with the calcium. The treatment of this condition has hitherto left so much to be desired that one gladly welcomes any therapeutic plan which holds out any prospect of success.

V. Proteids in Urine

Although their chemical relationship to each other renders natural the grouping together, under a common heading, of the substances belonging to the class of proteids which are met with in the urine under various morbid conditions, we should be justified, on clinical and pathological grounds, in placing them in quite distinct categories, seeing that the diagnostic indications afforded by the occurrence of the several members of the group are wholly different.

Certain proteids are normal constituents of the blood plasma which it is one of the most important functions of the renal epithelium to retain in the circulation, whilst allowing free passage to water and to the waste products of metabolism which require to be eliminated from the blood. Others, again, are foreign substances which only find their way into the blood, in any but insignificant quantities, under abnormal conditions, and upon these the renal epithelium exerts no such retentive action.

Thus whilst albuminuria, *i.e.* the excretion in the urine of easily appreciable quantities of serum-albumin, and paraglobulin, unless it be due to admixture below the kidneys, points to some failure of the renal epithelium to perform its allotted task in a satisfactory manner, albumosuria has no definite relation to the condition of the kidneys, but results from morbid processes elsewhere in the body, processes which lead to the formation of products the excretion of which in the urine reflects no discredit upon the kidneys.

It is, of course, true that the primary cause of albuminuria lies behind the kidneys in many instances, as for example in cases of valvular disease of the heart, but in such cases the effect results from secondary changes brought about in the kidneys, as, for example, by circulatory derangements producing venous congestion and impaired nutrition of the glomerular epithelium. The albuminuria is due to renal disorder, although such disorder is secondary and not primary.

Recent researches, and especially those of K. A. H. Mörner, leave little room for doubt that minute traces of albuminous material are present even in normal urine, but whether or no such proteid comes through the kidneys or is derived from some lower portion of the urinary tract, its presence does not in any way detract from the diagnostic importance of such quantities of albumin as can be detected by the ordinary methods employed in clinical work.

Albuminuria.—A number of tests are available for the detection of amounts of albumin which are clinically significant, of which the following are amongst those in most general use:—

The Heat Test.—A specimen of urine, which if turbid should have been passed through a filter, is placed in a test tube, and if alkaline should be rendered feebly acid with acetic acid. The upper part of the column of liquid is then boiled. If an opalescence turbidity or precipitate is formed this may be due either to albumin or to earthy phosphates, owing to changes in the arrangement of bases in the phosphates. If now a few drops of acetic acid be added a phosphatic precipitate will at once be redissolved, whereas an albuminous precipitate tends to become more flocculent. The boiling should be repeated after the addition of each drop of acid.

A few drops to 1 c.c. of nitric acid may be added instead of acetic acid, after boiling ; but if the urine be boiled after the addition of nitric acid, albumin if present may escape detection, owing to the formation of a soluble compound with the acid.

If carefully performed, the possible sources of error being taken into account, the heat test suffices for all ordinary purposes, but when their remains any doubt its indications should be checked by a second test.

Heller's Test.—The urine is allowed to flow gently on to the surface of nitric acid in a test tube. The pouring is best effected by placing the urine and the acid in two tubes which are inclined to each other at a very obtuse angle, or the acid may be introduced beneath the urine by means of a finely pointed pipette. If albumin be present an opaque white layer forms at the junction of the two liquids. Some pigmentation is usually observed owing to the oxidation of indigo-yielding substances. If nucleo-albumin be present a less defined and less opaque ring appears *above* the junction of the liquids. Another possible source of error is the precipitation of a ring of uric acid, which also lies above the junction, so that if the urine be albuminous two distinct rings, one due to uric acid and the other to albumin, are sometimes visible. The uric ring is removed by heating. Occasionally a ring of precipitated nitrate of urea is formed, but this is easily recognised by its obviously crystalline character. Both these latter sources of error may be eliminated by repeating the test with diluted urine. Lastly, the precipitation of copaiba resin must also be referred to.

The test is a delicate one, and as little as 0·002 per cent of albumin can be readily detected by its means. Still greater delicacy can be obtained by using a wine glass or small beaker in place of a test tube, and so observing a thicker layer of liquid.

In addition to serum-albumin and paraglobulin, hetero- and proto-albumoses yield positive results with this test.

Salicyl-Sulphonic Acid.—This test was independently suggested by Roch and MacWilliam. A few drops of a saturated solution of salicyl-sulphonic acid are added to the urine in the cold. If a precipitate forms it is due to albumin or to albumose, but the albumose precipitate disappears when the liquid is heated, whereas that of albumin persists. The test, although almost too delicate, is very useful for clinical purposes, and it has the advantage that with the exception of the proteids, including nucleo-albumin, no other substances present in the urine are precipitated by the reagent employed.

Picric Acid Test.—This test is extensively used. It may either be carried out as a ring test by pouring a saturated solution of picric acid upon the surface of the suspected urine, when if albumin be present a precipitate forms at the junction of the liquids, or the urine may be allowed to fall drop by drop into the picric acid solution, when the paths of the drops will be marked by opaque tracks if the urine contain albumin. Albumoses are also precipitated, but their precipitates disappear on heating, and certain non-proteid constituents, such as uric acid and creatinin, yield precipitates with picric acid. In connection with albumoses it must be pointed out that, as Huppert has shown, normal urine yields a flocculent precipitate when boiled with picric acid. When this test is employed it is necessary that the picric acid should be in excess.

Potassium Ferrocyanide Test.—Acetic acid is added to the urine in excess, and afterwards a few drops of a solution of potassium ferrocyanide; if albumin be present a dense white precipitate is formed. Albumoses and nucleo-albumin yield similar precipitates, but the albumose precipitates redissolve on heating.

If the acetic acid alone causes a turbidity from the precipitation of urates or the mucin-like substance, this should be filtered off before the ferrocyanide is added.

The Quantitative Estimation of Albumin.—For an accurate determination of the amount of albumin (serum-albumin and paraglobulin) in urine, it is necessary to separate and weigh these proteids, but for clinical purposes the method of Esbach affords results which are sufficiently reliable to meet the requirements. Into a specially graduated tube, which is provided with a stand, urine, rendered acid with acetic acid if necessary, is poured up to a certain mark, and a solution of 2 per cent citric acid and 1 per cent picric acid is added until a second mark is reached. The tube is then closed with an indiarubber cork and carefully shaken, so as to insure mixture of the liquids without the production of froth. After standing for twenty-four hours the height of the precipitate is read off by means of graduations which indicate the parts of albumin *per mille.* Variations of temperature constitute the chief source of error in the results.

If the urine be very rich in albumin, it requires to be diluted to a known extent before being placed in the albuminometer.

Significance of Albuminuria.—Except in those cases in which the albumin present is derived from lower portions of the urinary tract or is due to admixture of semen or vaginal discharges, readily detected albuminuria may, as has been already stated, be held to indicate some abnormal condition in the kidneys.

Speaking generally, it may be said that serum-albumin makes its way into the urine more easily than paraglobulin, a difference which may result, as Halliburton has suggested, from a greater size of the molecules of the latter proteid. Undoubtedly the relative quantities of the two varies widely in different cases, and it may be taken that a copious excretion of globulin points to a more severe degree of renal disease. When, however, we attempt to draw more detailed clinical inferences from this quotient it soon becomes apparent that the data available are as yet insufficient for the purpose, and the results obtained are apt to be contradictory. Halliburton, summing up our knowledge of these matters, after mentioning the points already referred to, adds that when both proteids are present the proteid quotient in the blood corresponds roughly to that in the urine, but that the latter is the more variable of the two, and that their variations do not necessarily correspond. It has been stated that the proportion of globulin is notably high in cases of lardaceous disease of the kidneys. Occasionally a globulin has been found alone in the urine, as in a remarkable case recorded by Byrom Bramwell and Noël Paton, in which it was deposited in crystalline form.

A rough notion of the amount of globulin present may be obtained, as Sir William Roberts pointed out, by allowing the urine to fall drop by drop into distilled water, when, if the proportion of globulin is considerable, the path of each drop, as it sinks through the water, is marked out by a milky streak, owing to the fact that this proteid is insoluble in pure water.

For accurate determinations of the relative amounts it is necessary to extract and weigh the albumin and globulin separately. To all the ordinary albumin tests the two proteids behave alike, and they are precipitated together.

The conditions under which albuminuria occurs may be grouped under several fairly distinct headings.

1. The albuminuria associated with organic disease of the kidneys, such as acute and chronic nephritis.

In acute nephritis the amount of albumin passed is usually large, and in the later stages of the disease, if the condition has become chronic, even larger proportions of albumin may be reached, and the urine may become almost solid when boiled. In such cases the presence of abundant tube-casts and their characters, as well as the general symptoms, are of even more importance than the amount of albumin in forming a diagnosis.

In chronic interstitial nephritis the excretion of albumin is as a rule scanty, except in the later stages when signs of cardiac failure are superadded, or when there is evidence of supervening parenchymatous trouble. In lardaceous disease of the kidneys the amounts of albumin excreted differ widely in different cases, perhaps in connection with the presence or absence of parenchymatous changes.

Other gross renal lesions, such as infarctions, may also give rise to albuminuria, and in all cases urine containing blood will naturally yield the reactions of albumin.

In ordinary cases of acute nephritis 1 per cent of albumin is frequently present, but this quantity is often greatly exceeded, and amounts exceeding 5 per cent are sometimes observed.

2. Circulatory disturbances are among the frequent causes of albuminuria, which is one of the ordinary accompaniments of impeded venous outflow from the kidneys. The result is the same whether the impeded outflow be due to a general backward pressure in the venous system, such as occurs in connection with valvular heart disease or with emphysema of the lungs leading to hypertrophy and dilatation of the right ventricle, or whether it be due to a more local venous obstruction caused by pressure on the renal veins or inferior vena cava exercised by the pregnant uterus, abdominal tumours, or large accumulations of ascitic fluid. In such cases the escape of albumin through the kidneys may be attributable in part to the increased *vis a tergo*, and in part to changes in the glomerular epithelium resulting from deficiency of oxygen in the blood.

A diminished supply of blood to the kidneys may produce a similar effect, and to this cause has been ascribed the albuminuria which may accompany diseases attended with profuse diarrhœa, such as Asiatic cholera, but here toxic influence may very probably come into play.

3. In fevers, albuminuria of slight degree is a very common symptom, and not only in such fevers as are apt to set up an acute parenchymatous nephritis, such as scarlatina and diphtheria. Such albuminuria may be in part due to circulatory disturbances, but the production of a toxic nephritis in the fevers referred to, and the occasional occurrence of nephritis as a complication of other febrile disorders, suggests a toxic origin, and the cloudy swelling so often observed in the kidneys post-mortem bears witness to changes produced in the renal epithelium by diseases of this class. Febrile albuminuria is to some extent dependent upon the height of the fever, and still more upon the length of the period over which it extends. Thus in typhoid fever a slight albuminuria is extremely common.

4. When the ureter has been temporarily occluded, as for example by a calculus, the removal of the obstruction is followed by albuminuria. According to Max Hermann, such albuminuria has its origin in secondary disturbances in the renal circulation resulting from the distension of the pelvis of the kidney by the urine which accumulates behind the obstruction.

5. A very interesting group of cases of albuminuria embraces those

connected with nervous disturbances, such as an epileptic fit, or more frequently a series of such fits occurring in rapid succession, or with graver accidents occurring in the central nervous system, such as cerebral hemorrhage. In considering such cases, which are not altogether easy of explanation, the possible existence of antecedent albuminuria must not be forgotten, and the special liability to cerebral hæmorrhage of patients who suffer from interstitial nephritis. In connection with epilepsy, the occasional occurrence of albuminuria in apparently healthy persons after violent exercise may be referred to.

6. Various poisons have the power of producing albuminuria, either by exerting a hæmolytic action and causing excretion of hæmoglobin, or, as is the case with cantharides, turpentine and phenol, by setting up a toxic nephritis.

7. There remains to be considered the so-called functional or physiological albuminuria. That minute traces of albumin are present even in normal urine has already been mentioned, and if, as Mörner evidently believes, such traces have a renal origin, it would appear not unlikely that somewhat larger amounts, recognisable by the ordinary clinical tests, should occasionally be excreted apart from any serious deviation from conditions of health. Moreover, we might expect that individual differences would exist in the power of the kidneys to prevent the passage of albumin from the blood into the urine.

Such a view gains in likelihood from the fact that functional albuminuria is usually intermittent, being called into existence by definite causes which differ in different cases. Sometimes it is absent while the patient is recumbent, and reappears on his resuming an erect posture; in other cases albuminuria only occurs after meals, in which connection it may be noted that the very free taking of uncoagulated albumin by the mouth is capable of producing a temporary albuminuria in a normal individual. Sometimes it follows a cold bath, and sometimes severe muscular exertion—causes which are active excitants of hæmoglobinuria—a suggestive fact.

On the other hand, such influences exert a conspicuous effect upon the excretion of albumin by patients with actual renal disease, and there are many who hold that the so-called functional albuminuria is always pathological, and that persons who exhibit it, if not actually the subjects of renal disease, are likely to develop structural changes in the kidneys in the course of time. Possibly among the cases so classed some are of one kind and some of another. In childhood and early youth the tendency to albuminuria not infrequently ceases entirely, but occasionally evidences of cardio-vascular changes are present which probably indicate an actual renal lesion.

The slight albuminuria which often accompanies the passage of oxalate crystals calls for special mention, as it may be that this is due to mechanical injury by the crystals, the slightest degree of the chain of events which may culminate in the profuse hæmaturia which sometimes results from the free consumption of rhubarb.

The question of physiological albuminuria is still an open one, concerning which investigators are divided into widely separated camps, but its importance, especially in relation to questions of life insurance, admits of no question.

8. Lastly, albuminuria may occur independently of renal lesions as the result of admixture of albumin below the kidneys derived from the renal passages or bladder, or from the admixture of other secretions. Urine which contains pus is always albuminous even when the formed elements

have been filtered off, and there are many sources from which pus may find its way into the urine, as in pyelitis, cystitis, tubercular disease and gonorrhœa. Chyluria offers another example of non-renal albuminuria. The admixture of semen is another cause, which may be recognised by the microscopic detection of spermatozoa, and in females admixture of vaginal secretion is a not uncommon cause of the presence of small quantities of albumin in the urine.

The Mucus-like Substance of Urine.—That a true mucoid material occurs in small quantities in urine, and constitutes the main proteid constituent of the nubecula, has been demonstrated by K. A. H. Mörner, but the bulk of the substance found in urine which has properties like those of mucus is not of this nature. Huppert identified it as a neucleo-albumin, but in his more recent investigations Mörner has shown that there exist in urine certain substances, viz. chondroitin-sulphuric acid, nucleic acid and taurocholic acid, which have the power of combining with albumin which may be present, with the formation of chondralbumins, neucleo-albumins, and tauralbumins. The albumin of normal urines is in such combinations, and as the combining substances are in excess, the addition of more albumin leads to further precipitation with acetic acid until all is exhausted, after which the excess of albumin remains uncombined. If any of the above acids be in excess their combination products may also be in excess, which probably explains the increase of mucin-like material in cases of jaundice, which may be attributed to an increased output of the bile acid.

The presence of such compounds is indicated by the formation of a turbidity when the urine is acidified with acetic acid in the cold. The precipitation is favoured by dilution of the urine, as the salts present tend to prevent it, and the same procedure removes the risk of the precipitation of urates by the acid.

The faint ring, situated 0·5 to 1 cm. above the junction of the liquids when Heller's test is performed, has been already alluded to, and this affords a further indication of the presence of the mucin-like substance.

Increased excretion of such material has been observed in a variety of conditions, such as vesical catarrh, leukæmia, and nephritis, as also in various forms of poisoning and in fevers such as typhoid and pneumonia. Its occurrence in jaundice has already been mentioned. Further investigations will doubtless teach us more as to the clinical significance of its occurrence and its connection with renal disease on the one hand and disease of the mucous membrane of the urinary passages on the other.

Fibrinuria.—When hæmorrhage occurs into the urinary passages the presence of clots in the urine may be observed, and in a few instances coagula have been passed which contain only a few scattered blood-corpuscles, as, for example, in a case of parenchymatous nephritis near its fatal ending, observed by Friedrich Müller, and as a result of cantharides poisoning in cases recorded by Senator and by Bartels.

In a case recently recorded by Trischitta, the urine, which was quite liquid when passed, readily coagulated after emission into a jelly-like mass, which could only be decanted with difficulty. The patient was a woman aged twenty-nine, who had suffered from pain in the region of the right kidney, but no satisfactory explanation of the fibrinuria was forthcoming.

It is, however, in chyluria that fibrinuria is most conspicuous, and in this condition the urine will sometimes clot so as to form a mass resembling blanc-mange.

Albumosuria (*Peptonuria*).—There is some confusion in the use of the terms albumosuria and peptonuria, which arises from the application of the name peptone to different substances.

The peptone of Kühne, the ultimate product of the digestion of proteids, is characterised by the fact that although it yields the biuret and other proteid reactions, it is not precipitated by saturation of its solutions with ammonium sulphate. Several investigators have sought for such true peptone in normal and morbid urines without success, and the statement is usually made that it does not occur in the renal excretion unless after direct injection into the circulation. However, in a quite recent paper, Ito claims to have detected the peptone of Kühne, in association with albumose, in cases of pneumonia before and during the stage of resolution, in a case of advanced pulmonary phthisis, and also in puerperal cases.

The condition spoken of as peptonuria is characterised by the presence in the urine of a proteid substance agreeing in properties with the peptone of Brücke, and which is more correctly described as a deutero-albumose. Whereas some writers prefer the more correct name of albumosuria for this condition, others limit the use of this designation to cases in which proteids are present, which resemble in their properties the digestive proto- and hetero-albumoses. The proteid resembling hetero-albumose, which is now usually spoken of as the Bence-Jones proteid, from the name of its discoverer, has a special diagnostic importance, but is of very rare occurrence. On the other hand, no very definite clinical distinction can as yet be drawn between cases in which proto-albumose occurs and the much commoner ones in which the proteid present has the characters of deutero-albumose.

Detection of Albumoses in Urine.—When present in sufficient quantities the albumoses may be detected by tests applied directly to the urine, provided that albumin be absent. When albumin is present it requires to be got rid of as a preliminary measure before the tests for albumoses are applied.

The fact that a urine which is free from albumin yields the biuret test with copper-sulphate and an alkaline hydrate must not be relied upon as indicating the presence of albumose, as some non-proteid constituents of urine yield a pink tint with these reagents, and the chief of these is urobilin.

Nitric acid added drop by drop precipitates the Bence-Jones proteid and proto-albumose, and the precipitate so formed redissolves on healing and reappears on cooling. Deutero-albumose, on the other hand, is not so precipitated unless sodium chloride has been previously added. A precipitate of urates thrown down on the addition of the acid may simulate an albumose.

Salicyl-sulphonic acid is a very useful reagent for the detection of albumoses, as the precipitates which they yield are dissolved on healing and reappear on cooling.

For the preliminary removal of albumin mere boiling does not suffice, and the removal is best effected by precipitation with ferric chloride from the neutralised urine.

For the precipitation of albumoses, where scantily present, phospho-tungstic acid or tannin may be employed, or Devoto's method, which is based upon the fact that albumin and globulin become completely insoluble when boiled with a saturated solution of ammonium sulphate, whereas the precipitate of albumose so obtained may be redissolved in water. This method has the advantage that no special proceeding for the removal of albumin is required. The recognition of the Bence-Jones proteid will be spoken of later.

Clinical Significance of Albumosuria.—By the researches of a number of observers, among whom von Jaksch, Hoffmeister, Devoto, and Sidney Martin may be mentioned, a mass of information as to the clinical significance of albumosuria or peptonuria has been collected. As has been already pointed out, the presence of albumoses is not indicative of renal disease, but of their presence in the blood. Huppert has well pointed out that the excretion of albumoses in the urine indicates the breaking down of albuminous tissues somewhere in the body. Thus albumosuria may occur during the early days after delivery, when its appearance may be attributed to the rapid involution of the uterus. In another class of cases it results from the tissue changes which occur in an infarcted area, from which the blood-supply has been cut off by the lodgment of an embolus in the artery which feeds it. The rapid breaking down of tissues which occurs in the liver in cases of acute yellow atrophy and phosphorus poisoning may also cause albumosuria, and it has occasionally been met with in cases of cirrhosis hepatis. A like result may follow from degenerative changes in malignant growths, and in cases in which the intestines are the seats of extensive ulcerative lesions.

When exudations rich in leucocytes are undergoing absorption the conditions favourable to the production of albumosuria are naturally present, and both in cases of pneumonia during the stage of resolution, and in connection with suppurative processes, such as empyema and bronchiectasis, the phenomenon is often to be observed. These are indeed the most important varieties of albumosuria from the clinical standpoint.

It should be mentioned that some observations which have been recorded are not easily to be explained on the above view, as, for example, the occasional detection of albumoses in urine in the earlier stages of pneumonia, and Fischel's observations on the occurrence of albuminuria in pregnancy for some weeks before delivery.

Histon has been detected in the urine by Krehl and Matthes in cases of peritonitis, pneumonia, erysipelas, and scarlatina, and by Kolisch and Burian in a case of lymphatic leukæmia.

The Bence-Jones Proteid.—In the rare cases in which this substance is met with in urine it is usually present in large amount, and may be recognised by methods which are of easy application in ordinary clinical work. In Bradshaw's case it was partly in the form of a solid sediment. Unlike deutero-albumose it is precipitated on heating the urine, which becomes turbid at the low temperature of about 40° C. On further heating a bulky flocculent precipitate is formed which clings with peculiar tenacity to the sides of the containing test-tube. Precipitation is complete at about 58°-60° C. On further heating, and especially if a few drops of acetic acid have been added, the precipitate almost completely or completely disappears, and the urine is left nearly or quite clear. The low temperature at which the precipitate forms and the behaviour on further heating are quite characteristic and serve to differentiate the Bence-Jones proteid from all other proteids met with in urine. With Heller's nitric acid test the substance yields a ring as do albumin and globulin.

The nature of the Bence-Jones proteid has been specially studied by Magnus Levy, who arrived at the conclusion, that in spite of its resemblance to hetero-albumose, its proper place is among the albumins rather than the members of the albumose group. It is interesting to note that Zülzer has found a proteid with identical properties in the urine of dogs poisoned with pyridin.

The clinical importance of the Bence-Jones proteid is due to its association with myelomatous and myelosarcomatous growths in the bony skeleton, such growths having been present in cases which have come to post-mortem examination, and having been successfully diagnosed during life on the ground of the presence of this substance in the urine. Until the last few years only some five cases of its occurrence were known, but of recent years the subject has received much attention from Bradshaw and others in this country, and also from continental observers, with the result that fresh examples have rapidly multiplied. These later observations have tended to supply confirmatory evidence of the special diagnostic significance of the condition.

Hæmoglobin.—The last proteid to be considered is hæmoglobin, but as hæmaturia and hæmoglobinuria have both been treated of in special articles (*q.v.*) they need only be briefly referred to here. It will suffice to recall the fact that hæmaturia implies hæmorrhage from some portion of the urinary tract, whereas the cause of hæmoglobinuria lies behind the kidneys, in the presence of free hæmoglobin in the blood plasma.

Urines which contain hæmoglobin yield the ordinary tests for albumins, and the failure to obtain positive results by these tests suffices to exclude its presence.

The blood-pigment may be present in the urine either as oxyhæmoglobin or as methæmoglobin, and often both are present together. The presence of methæmoglobin is recognised by the dark absorption band in the red which forms the most conspicuous feature in its spectrum, and the familiar absorption bands of oxyhæmoglobin are usually conspicuously visible, especially in urines which have a pink colour.

Methæmoglobin may become transformed into oxyhæmoglobin when the urine is allowed to stand, and the colour of the liquid changes, at the same time, from brown to pink. In alkaline urines, which often have a peculiar livid tint, some reduction of oxyhæmoglobin takes place in the deeper layers, which often exhibit the bands of reduced hæmoglobin and of oxyhæmoglobin in superposition. The spectroscopic test is of great value for the recognition of blood pigment, but it must be borne in mind that, when only a trace is present, and that in the form of methæmoglobin, the absorption bands may be very faint and quantities may be overlooked which are readily detected by the guaiacum test.

This latter test is of great delicacy, but may mislead, owing to the fact that other substances met with in urine yield a similar blue colour, but a negative result is of much value in excluding the presence of hæmoglobin, always providing that the reagents are freshly prepared and active.

A few drops of tincture of guaiacum are added to some ozonic ether (an ethereal solution of hydrogen peroxide), and the mixture is allowed to run upon the surface of the urine. If blood be present a blue ring appears in the ether near the junction of the liquids, and on gently shaking, the whole layer of ether becomes blue.

The urine of patients who are taking iodide of potassium yields the blue colour with great intensity, but the reaction is more slowly developed.

Heller's test is performed as follows:—To some urine in a test-tube an equal volume of liquor potassæ is added, and the mixture is boiled. The flocculent phosphatic precipitate which forms is coloured brown, and on further boiling usually assumes a pink tint. At this stage, as Arnold has pointed out, the spectrum of hæmochromogen, which is easy of recognition, is clearly seen when the phosphatic precipitate is examined with the spectroscope. When this is the case the presence of blood pigment may be confidently affirmed.

Chrysophanic acid, which occurs in the urine of patients taking rhubarb or senna, imparts a pink tint to the phosphate precipitate, which however shows no definite absorption bands; hæmatoporphyrin is also carried down, but is seldom present in such quantities as are likely to lead one into error.

The microscopic detection of red blood corpuscles is the only certain test of hæmaturia, as distinguished from hæmoglobinuria.

Pyuria.—The presence of pus in the urine forms the subject of a special article, *q.v.*, vol. x.

VI. The Chief Nitrogenous Constituents of Urine

The Total Nitrogen.—A healthy adult excretes some 10-16 grammes of nitrogen in his urine in the course of twenty-four hours. Of this the great bulk (84-90 per cent) is contained in urea, and the remainder is distributed amongst a number of other constituents, such as uric acid, kreatinine, the xanthin bases, ammonia, indoxyl compounds, and the pigments, and, under morbid conditions, leucin, tyrosin, the diamines, cystin, and albumin. The nitrogenous constituents are for the most part products of proteid metabolism, and their amount is largely determined by the quantity of nitrogenous materials contained in the food, provided that fats and carbohydrates are at the same time given in sufficient amounts. However, the output of urea which follows a meal is not directly derived from that meal, but chiefly from the metabolism of the tissue proteids. Under ordinary conditions when a fixed diet is given a condition of nitrogenous equilibrium is established, the output of nitrogen in the urine being equal in amount to the intake after subtraction of the quantity contained in the fæces; or in other words, the nitrogen in the urine and fæces equals that taken in the food. If, within certain fairly wide limits, a person in whom such nitrogenous equilibrium has been established is placed upon a diet richer or poorer in proteids than that which he was previously taking, the organism will adapt itself to the altered conditions within a few days, and nitrogenous equilibrium will be re-established upon a higher or lower plane.

The administration of excess of carbohydrates and, in a less degree, of fats to a person in nitrogenous equilibrium tends to spare the tissue proteids, and reduces the nitrogenous output, and a diminution of these constituents of the diet has a contrary effect. In fevers, as was first shown by Huppert, the output of nitrogen is greatly increased beyond that of healthy persons on a similar diet, and an increase is observed in other conditions which lead to increased proteid metabolism, such as *diabetes mellitus* and malignant disease. Although urea contributes so large a proportion of the total nitrogen, the results of estimations of these two factors do not altogether agree, seeing that under a variety of conditions the relative proportions of the several nitrogenous constituents of the urine undergo conspicuous variations. This is specially marked in certain grave hepatic diseases, in which the output of urea may undergo a remarkable relative diminution, whereas there is usually a compensatory increase of the ammonium salts.

In renal disease a diminution of the total nitrogen below the quantity corresponding to the amount ingested results from a diminished eliminative power of the kidneys. Von Noorden and Ritter found that this retention of nitrogenous products was not continuous in chronic renal diseases, but that a period of low excretion is followed by one of normal or increased output. This may account for the conflicting results which have been obtained in observations which have usually extended over short periods only. Von Noorden points out that in cases of chronic parenchymatous nephritis the retained nitrogen may amount to several grammes per diem, and that if such retention were continuous enormous accumulation would result, seeing that the excretion by other channels, such as the skin, is very limited. Vogel and Schmoll found that a similar diminished excretion of total nitrogen occurs in gouty persons apart from any clinical evidence of renal disease. Magnus Levy confirmed this for the convalescent period, but observed, on the other hand, a greatly increased output of nitrogen during the acute attack.

For the estimation of the total nitrogen excretion Kjeldahl's well-known method is employed.

Urea.—Some 30 grammes of urea are excreted by a healthy adult in the twenty-four hours, forming about 2 per cent of the urine.

The estimation of urea has become a common clinical proceeding, and most hospital wards are provided with the necessary apparatus for the purpose, but it is permissible to doubt whether the results obtained are, as a rule, of much clinical value. It will be clear from what has gone before, that in forming any conclusions from the urea excretion, the amount of nitrogen contained in the food of the patient must be taken into account, and in renal cases this is as a rule much below the usual quantity. It is hardly necessary to point out that unless the total urine of the twenty-four hours has been collected and measured, and unless the specimen employed has been taken from this total, the results obtained are of no value at all.

In fevers the output of urea is markedly increased, and a still more conspicuous increase, up to 100 grammes or more in the day, is observed in *diabetes mellitus.* The increase in fevers is usually associated with a diet poor in nitrogen, whereas in diabetes the contrary is the case. However, the great increase in the latter disease is far too pronounced to be wholly attributable to the proteid diet, and can only be referred to an abnormally active tissue metabolism. In fevers the increase doubtless has a similar cause, but it is not proportionate to the height of the fever, and in diseases ending in a crisis, such as pneumonia, the maximum excretion may occur shortly after the crisis.

Diminished excretion of urea is observed in some nervous diseases and has been often noticed in Addison's disease, in which it perhaps has a nervous origin. Otherwise a marked diminution of the urea output is usually due to one of two causes, viz., diminished formation, such as results from certain diseases of the liver, which organ is the chief seat of urea formation, or diminished excretion, such as occurs in various forms of renal disease.

The diminished output of urea in hepatic diseases reaches its most conspicuous development in cases of acute yellow atrophy, in which the excretion may be practically abolished. It is seen in a less pronounced form in acute phosphorus poisoning, and in some cases of cirrhosis hepatis, in which disease, as is well known, the hepatic parenchyma may undergo marked degenerative changes. Under such conditions the abnormal nitrogenous substances leucin and tyrosin may make their appearance in considerable quantities, and the decrease of urea is usually attended by an increased excretion of ammonia, which may either be due to a failure of the conversion which it normally undergoes in the liver, or may result, as in diabetes, from the formation of abnormal acids.

As regards parenchymatous and interstitial nephritis, what has been said of the total nitrogen excretion applies equally to that of urea, which may be below the normal, or even increased at different periods in a given case. Some importance has been attached to the relative excretion of phosphates and of urea in renal disease, as affording evidence of the portions of the renal epithelium chiefly affected. Seeing that the excretion of phosphates takes place from the glomeruli, and that of urea from the renal tubules, we should expect a nephritis which is chiefly glomerular to specially affect the phosphatic output and one chiefly tubular that of urea. Such differences have been actually observed.

The method employed for the estimation of urea in clinical work is based upon its decomposition by sodium hypobromite with the liberation of nitrogen and carbon dioxide. The absorption of the carbon dioxide is ensured by the presence of an excess of sodium hydrate in the hypobromite solution, and the nitrogen is collected and measured over water. The hypobromite solution employed should always be freshly prepared.

Various forms of apparatus have been devised for such estimations, and these will be found described in works on urinary analysis. In order that the results obtained may have an approach to accuracy, the readings of the column of nitrogen should be corrected, at least for the temperature of the air, if not for barometric pressure and the tension of aqueous vapour. The apparatus is usually so graduated that the percentage of urea in the urine tested may be read off directly.

Uric Acid.—The excretion of uric acid by healthy adults varies within somewhat wide limits, viz., from 0·2 to 1·25 grammes in the twenty-four hours. The amount is greater with a flesh than with a vegetable diet, and recent researches render it highly probable that, as Horbaczewski first pointed out, the nuclein of the food and tissues is the source of the uric acid excreted in the urine, and that it is not a product of proteid metabolism in general. Glandular structures such as thymus, which are rich in nuclein, have a specially conspicuous effect in increasing the excretion of uric acid when they are taken as foods. Owing to their sparing solubility uric acid and its salts are apt to proclaim their presence in the urine and tissues, and have consequently attracted much attention from clinical observers and chemical pathologists alike.

Whilst it is the view of the majority that the deleterious effects which uric acid produces in the organism are limited to those which result from its deposition, or that of its salts, in solid form, there are some who maintain that this substance exerts a toxic action even when in solution in the body fluids, and that to its presence there a large number of morbid symptoms are due. Haig lays great stress upon the relative variations in the output of uric acid and urea, as affording evidence of the retention of uric acid in the tissues, or the expulsion therefrom of quantities previously retained.

The excretion of uric acid is increased in febrile diseases, and a marked increase has been sometimes observed in cases of pernicious anæmia. The most conspicuous increase is met with in leukæmia, but even in this disease quantities as large as 4 or 5 grammes in the twenty-four hours, although occasionally met with, must be regarded as exceptional. More usually the output is about twice the maximum normal amount. In leukæmia there is a relative as well as an absolute increase, and the proportion of urea to uric acid may be as low as 9 : 1 instead of 50 : 1, which is about the average normal ratio.

Owing to the part which uric acid undoubtedly plays in the pathology of gout, a peculiar interest attaches to its excretion in that disease, but the results of investigations directed to this point are far from being as conclusive as could be wished, or as was foreshadowed by some of the earlier investigations in which the unsatisfactory method of Heintz was employed. The variations observed are by no means extreme, and the results are by no means uniform in different cases. Moreover, the wide individual differences in the uric acid excretion of normal subjects render it peculiarly difficult to estimate the importance of any but very marked variations. Indeed von Noorden, writing in 1893, expressed the opinion that the figures obtained in gouty cases show no important differences from those obtained with healthy persons and sufferers from various diseases other than gout. A study of the results obtained by trustworthy methods of estimation, and especially those of Fawcett, point to a low average excretion of uric acid by gouty patients in the intervals between attacks, and an increased output during acute attacks. The results obtained in cases of chronic nephritis are not more conclusive as regarding the retention of uric acid by diseased kidneys.

The deposition of amorphous urates and of crystalline uric acid from the urine has no necessary connection with excessive excretion, although this is doubtless one of the causes of such deposition. The other causes which contribute to the result will be spoken of in the sections which deal with urinary sediments and with calculi respectively. The estimation of uric acid has of recent years been deprived of much of its difficulty, and in Hopkins's method we have a means of making such estimations simply and with as much accuracy as is attained to with more complex methods. It is based upon the fact that the uric acid is completely precipitated in the form of ammonium urate when the urine is saturated with ammonium chloride. From the precipitate of ammonium urate, dissolved in a small quantity of hot water, the uric acid is set free by means of hydrochloric acid. The precipitated uric acid is collected upon a filter and washed, and afterwards dissolved by means of sodium carbonate and titrated, in the presence of sulphuric acid, with a vigintinormal solution of potassium permanganate.

The Xanthin Bases.—Several different bases allied to uric acid and often classed with it under the general name of alloxuric substances, constitute a very small fraction of the total nitrogenous constituents of urine. Of these xanthin is the most important, and has been met with as a crystalline sediment, and in a very rare variety of calculus.

Much study has been devoted, of recent years, to the variations in the excretion of such bases, sometimes by methods which are not satisfactory. As yet the fluctuations in their amounts have hardly acquired any definite clinical importance, and the methods employed for their estimation are complicated and difficult.

Like that of uric acid, the output of the xanthin bases is increased by a diet rich in nuclein, and in connection with leucocytosis. In leukæmia a marked increase has been frequently but not constantly observed, and it should be mentioned that Babinsky found their amounts excessive in cases of acute nephritis. The increase described by Kolisch as occurring in gout has not been met with by other observers.

Kreatinine.—As compared with those of uric acid, the variations in the excretion of kreatinine in the urine have attracted but little attention from clinical workers. It is never thrown down as a sediment from the urine, and no untoward results can be ascribed to its presence in excess.

Neubauer found that in health the kreatinine excreted by the kidneys in periods of twenty-four hours varied between 0·6 and 1·3 grammes, or was, roughly speaking, 1 gramme. Macleod has recently obtained higher figures, viz., an average of 2·098 on flesh diet, and 1·064 on a diet free from kreatine.

The kreatinine of urine is partly exogenous and partly endogenous, the former portion being derived from the kreatine of food, the latter being a product of tissue metabolism. It is therefore important that in studying the variations of the endogenous excretion the patient should be placed upon a kreatine-free diet.

An increased output has been observed by Grœco and Moitessier after violent muscular exertion, and it may be stated generally that the amount is increased when metabolism is active, and diminished when it is sluggish, and the excretion shows a parallelism to that of urea. During acute fevers, such as pneumonia and typhoid fever, the excretion of kreatinine is increased, but it falls below the normal during convalescence from these diseases. In anæmic states, in marasmus, and in association with tuberculous processes, a diminution has been observed.

In cases of progressive muscular atrophy, and in pseudo-hypertrophic paralysis, a diminished output has been observed, but Macleod has failed to find such diminution in cases of muscular atrophy. Macleod has recently demonstrated a very conspicuous diminution in cases with marked splenic enlargement. This diminution, which attains to as much as 50 per cent of the normal excretion on kreatine-free diet, was equally conspicuous in cases in which the leucocytes of the blood were diminished in number, and in those in which there was marked leukæmia.

The presence of kreatinine in the urine is easily demonstrated, but its mere detection is of no clinical value. For its quantitative estimation advantage is taken of the fact that it forms a sparingly soluble compound with zinc chloride. For a description of the processes available the reader is referred to works on urinary analysis.

It is interesting to note that it was the green fluorescence observed when working at the estimation of kreatinine by a zinc chloride method, that led Jaffé to the discovery of urobilin, to the compound of which pigment with zinc chloride that fluorescence is due.

VII. Some Abnormal Nitrogenous Constituents. Diamines, Leucin and Tyrosin.

Diaminuria.—Of recent years two of the members of the class of diamines, viz. cadaverine or pentamethylene diamine, $H_2N(CH_2)_5NH_2$, and putrescine or tetramethylene diamine, $H_2N(CH_2)_4NH_2$, have been repeatedly met with in the urine in cases of cystinuria, and sometimes in the fæces of cystinuric patients also. The original case in which this association was observed by Baumann and Udranszky was peculiar in the constancy with which the diamines were present both in urine and fæces over a period of years. In some of the recent cases they have only been found at intervals, and in some not at all in a few observations. In no other instance has the same high proportion of diamines been found in the fæces. The two bases have sometimes been found in association, more often cadaverine has alone been found, and very seldom putrescine alone has been isolated. In the case referred to the quantities obtained amounted to some 0·2-0·4 grammes of the benzoyl compounds of the mixed diamines in the urine of twenty-four hours. In another case examined by P. J. Cammidge and the present writer similar quantities were obtained from the urine on two occasions only during a series of examinations extending over about a month.

In no other condition have these diamines been found in amounts capable of detection in the urine of a single day, but in large quantities of the urine of patients with pernicious anæmia, collected and concentrated down, William Hunter was able to detect their presence in smaller quantities. From normal and most morbid urines they appear to be wholly absent.

It is impossible to avoid the conclusion that some intimate connection exists between the excretion of cadaverine and putrescine and cystinuria, but no approach has yet been made to a solution of the problem of the nature of this connection.

The occurrence of the diamines in the fæces of their patient in larger quantities than in his urine naturally led Udranszky and Baumann to attribute their formation to bacterial action in the intestine, seeing that they are well-known products of bacterial activity. There are, however, no grounds for supposing that cystin is formed in the intestine, and there is no question that the excretion of cystin may continue unchecked when the diamines are absent for a time both from urine and fæces. Moreigne and C. E. Simon have, on the other hand, suggested that in these cases the diamines, as well as cystin, may be products of tissue metabolism.

Two methods are in use for the detection of diamines in urine. That of Udranszky and Baumann involves the shaking of the total day's urine with benzoyl-chloride and an excess of sodium hydroxide solution. From the precipitate formed, which consists in part of earthy phosphates, the benzoyl compounds of the diamines are extracted with hot alcohol. On pouring the alcoholic solution into water the benzoyl diamines, if present, separate in crystalline form.

In the alternative process of Stadthagen and Brieger the diamines are obtained in the form of crystalline picrates.

Leucin and Tyrosin.—These are abnormal constituents of urine which are usually met with in association. Both are members of the class of amido-acids, but while leucin belongs to the fatty series, being amido-caproic acid ($C_6H_{13}NO_2$), tyrosin is an aromatic compound, viz. par-oxyphenyl-amido-propionic acid. Both are products of proteid decomposition.

It is especially in cases of acute yellow atrophy of the liver that these substances appear in large amounts in the urine, so that their presence becomes an important clinical feature of that disease. In cases of acute phosphorus poisoning they are occasionally met with, but in smaller quantities. Their occurrence in phosphorus poisoning has even been denied, and von Jaksch has very seldom met with them in such cases.

In severe febrile disorders, such as variola, they have also been found, as also in the urine of pernicious anæmia by von Noorden and Laache, and in leukæmia by Prus.

In acute yellow atrophy of the liver as much as 1·5 gramme of tyrosin has been present in the urine of twenty-four hours.

The view generally accepted of the cause of their so abundant presence in this disease is that leucin and tyrosin are intermediate products of proteid metabolism, and that under normal conditions the nitrogen contained in them passed through the stage of ammonia, to take part in the formation of urea in the liver. When, however, the liver cells have undergone extensive destruction these further changes are escaped, and leucin and tyrosin appear in the urine. This view receives much support from the very conspicuous diminution of the urea excretion in the disease in question. Von Noorden, on the other hand, is inclined to attribute their appearance to the action of bacteria in the tissues, and ascribes the smaller quantities found in phosphorus poisoning and severe anæmias to absorption of leucin and tyrosin from the intestine, and failure of the ordinary destructive processes.

Under normal conditions tyrosin administered by the mouth certainly does not appear as such in the urine, and even the benzine ring contained in it is broken up. The only exception to this rule is in the rare condition known as alkaptonuria, which will be described in a later section (p. 116).

When tyrosin is present in considerable amounts some of it is usually deposited from the urine as a crystalline sediment, whereas leucin is very seldom so deposited.

For their detection the following method may be employed:—the urine of twenty-four hours is precipitated with basic lead acetate and filtered. From the filtrate the lead is removed by passing a stream of sulphuretted hydrogen through it. The lead sulphide is filtered off, and the liquid is evaporated to a syrupy consistency. On standing leucin and tyrosin crystallise out, the former in needles, the latter in greenish spherules. It is usually better to remove the bulk of the urea present in the residue with a small quantity of absolute alcohol. The residue is then boiled with dilute ammoniacal alcohol, the solution is filtered, evaporated to a small bulk, and allowed to stand.

Their crystalline forms usually suffice for the recognition of leucin and tyrosin.

The needles of tyrosin are insoluble in acetic acid, but dissolve in ammonia and in hydrochloric acid; but if the quantity suffices, and if full certainty is desired, some of the special chemical tests should be applied.

VIII. Sugars in Urine

Glucose.—Seeing that diabetes mellitus and glycosuria have been dealt with in separate articles, it will be unnecessary to enter here upon any discussion of the conditions which lead to the presence of glucose in the urine, and it will only be necessary to refer to the chief tests for its detection which are in use for clinical purposes.

The simplest of these, known as Moore's test, is not a very delicate one, but is sometimes useful when the reagents for better tests are not available. To some of the suspected urine, placed in a test-tube, some liquor potassæ is added, and, after mixing, the upper portion of the column of liquid is boiled. If sugar be present a deep brown colour is produced by its decomposition. It must be remembered that even normal urine shows a distinct darkening of tint under such treatment, and only the development of a pronounced brown colour affords evidence of the presence of sugar.

In the remaining tests advantage is taken of one or other of the conspicuous properties of glucose, viz. its power of reducing metallic salts, of undergoing fermentation, of rotating the polarised ray, and of forming with phenyl-hydrazin an insoluble crystalline compound, glucosazone.

The reduction tests are of great service, but it must not be forgotten that they only afford evidence of the presence of a reducing substance, which is not necessarily sugar, but which, if present in large amount, is probably of that nature.

Trommer's test is performed as follows :—The urine is rendered strongly alkaline with liquor potassæ and a solution of cupric sulphate is added, drop by drop, until the precipitate formed is not wholly redissolved. If sugar be present a reduction of the copper salt to cuprous hydrate occurs on heating and an orange-red precipitate appears.

It is more convenient to employ freshly mixed Fehling's solution for the test. The Fehling's solution and the urine should be heated in separate test-tubes and mixed when hot. The mixture may be further heated if necessary.

If sugar be present in considerable quantity the reduction occurs before the liquid is raised to the boiling-point, and when this is so the presumption that it is due to the presence of sugar is very strong. When, on the other hand, sugar is only present in traces it may be necessary to boil the liquid before a scanty reduction occurs, often with the production of only a pale green opacity. Under such circumstances the presence of sugar requires to be confirmed by other tests, as even normal urine contains reducing substances, among which kreatinine and uric acid are the chief. Reducing substances also appear after the administration of certain drugs, such as salicylic acid, chloral, chloroform, and glycerine, and among other reducing agents lactose glycuronic acid and pyrocatechin call for mention. Homogentisic acid is an energetic reducing agent, and alkapton urines, in which alone it is present, react with copper solutions as readily as glycosuric ones. However, alkaptonuria is extremely rare, and the conspicuous blackening by the alkali, which occurs at the same time, is very characteristic.

The bismuth test of Almén and Nylander is not very often employed in this country. The reagent is prepared by dissolving 4 grammes of sodium potassium tartarate in 100 c.c. of an 8 per cent solution of sodium hydroxide, and, after warming, basic nitrate of bismuth is added as long as it is dissolved. One part of the test solution is added to ten parts of the suspected urine, and the mixture is boiled for a few minutes. If sugar be present the liquid blackens. This test is not applicable to albuminous urines, as in them the black sulphide of bismuth is apt to form, and other reducing substances met with in urine yield a positive reaction, as also does chrysophanic acid derived from rhubarb or senna. On the other hand alkàpton urines do not respond to this test.

The phenyl-hydrazin test, introduced by von Jaksch, is thus performed :—Two parts (von Jaksch describes as a part as much as can be taken on the point of a knife) of chemically pure phenyl-hydrazin hydrochloride and three parts of sodium acetate, are added to 6-8 c.c. of the urine in a test-tube. The test-tube is warmed, and if solution is not complete some water is added. The test-tube is then allowed to stand in boiling water for half an hour, or better for an hour, and is then placed in a beaker of cold water. On cooling a yellow crystalline precipitate of phenyl-glucosazone falls, and this precipitate consists of yellow needles arranged in rosettes, which are larger if the liquor is allowed to cool more slowly.

The test is an extremely delicate one, almost too delicate indeed, seeing that crystals of phenyl-glucosazone may even be obtained from normal urines. Other sugars and glycuronic acid yield similar crystalline compounds, which may be distinguished by their crystalline forms, or much better by their melting-points, which may be determined after the crystals have been removed, washed, and dried. The melting-point of pure phenyl-glucosazone is 204°-205° C., but impurities may, of course, cause a considerable lowering of the melting-point.

The fermentation which it undergoes with yeast offers one of the surest ways of detecting sugar in urine, and also supplies a simple and fairly accurate means of estimating its amount. This is the principle of Roberts's method, which is so extensively employed in our hospitals. Specimens of the urine are placed in two bottles provided with grooved corks to allow of the escape of gases. Into one of the bottles a small piece of German yeast is introduced, and both are allowed to stand in a warm place for twenty-four hours. After the bottles have cooled the specific gravity of both specimens is taken, and the loss of specific gravity of the fermented as against that of the control specimen affords a measure of the amount of sugar which has been destroyed. A difference of 1° corresponds roughly to one grain of sugar in the ounce of urine. Care must be taken that the bottles do not become overheated, with the result that the activity of the yeast is inhibited. Estimation by measurement of the carbon dioxide formed is less satisfactory, but the collection of the gas forms a ready method of demonstrating the occurrence of fermentation. It must be remembered, however, that a small quantity of gas is formed by the auto-fermentation of yeast.

More accurate results are obtained by the titration of urine with Fehling's solution.

The solution in question is made up in two portions, one of which is prepared by dissolving 34·64 grammes of cupric sulphate in 500 c.c. of water, the other by the addition of 173 grammes of sodium-potassium tartarate to 100 c.c. of sodium hydroxide solution (sp. gr. 1·34) and dilution to 500 c.c. The two solutions should be mixed in equal parts before use. The fresh admixture is of importance, because when the mixed Fehling solution is kept for some time reduction is apt to occur on boiling, owing to a partial conversion of tartaric into racemic acid. Such reduction may give rise to serious diagnostic errors.

The urine is placed in a burette and if rich in sugar should be diluted with water to a known extent. 10 c.c. of Fehling's solution, diluted with some 40 c.c. of water, are placed in a porcelain dish and are kept boiling during the process of titration. When the urine is run into it gradually from the burette the familiar orange precipitate of cuprous oxide is thrown down and the blue colour of the solution becomes paler. Eventually, when reduction is complete, the liquid above the precipitate is rendered colourless, and the amount discharged from the burette is then read off. A preliminary rough determination of the reducing power should first be made, after which the urine may be further diluted to a known extent if it appear desirable. Owing to the presence of the orange precipitate the exact point at which the blue tint disappears is rather difficult to estimate, and the following means may be resorted to. Upon a porcelain tile a number of drops of a solution of potassium ferrocyanide are placed by means of a glass rod, and to each a drop of acetic acid is added by the same means. When reduction approaches completion a drop of the clear liquid above the precipitate is removed by the stirring rod and added to one of the drops upon the tile. If a brown colour results the copper is not completely reduced, and after the further addition of urine from the burette the test may be repeated until no further brown colour is obtained.

Dilution of diabetic urine to five or ten times its volume is usually desirable, and the amount of diluted urine required to reduce the 10 c.c. of Fehling's solution used will contain 0·05 gramme of glucose. From this the amount present in a given quantity of the original urine is readily determined.

Pavy's solution, which is a modification of Fehling's with the addition of ammonia, has the advantage that no precipitate is formed with it, the cuprous oxide being held in solution by the ammonia and the change of tint being readily observed. It has, however, the disadvantage that ammonia fumes are abundantly given off by the boiling liquid. This can be overcome, at the cost of some complication of the apparatus, by carrying out the reduction in a corked flask provided with an escape tube for the fumes.

The rotation of the polarised ray may also be used for the estimation of sugar in urine by means of the saccharimeter, which will be found described in works on urinary analysis. It is advisable to decolorise the urine, as a preliminary step, by means of alumina paste and subsequent filtration, and the results obtained by this method are impaired by the presence of other reducing substances, such as glycuronates. In diabetes the presence of considerable quantities of the lævo-tatory β oxybutyric acid may greatly counteract the dextro-rotatory influence of the glucose and introduce important errors.

For other volumetric methods, such as those of Knapp, in which a standard alkaline solution of mercuric cyanide is employed, the reader is referred to the text-books.

Lactose or milk sugar is often met with in small quantities in the urine of nursing women, and more abundantly when suckling is abruptly discontinued, as is not infrequently the case on admission to a hospital. The recognition of the occurrence of lactosuria under such conditions is important for the avoidance of errors of diagnosis. When the conditions which lead to lactosuria are present it may be recognised with sufficient certainty by the facts that the urine reduces Fehling's solution, although not very readily, and yields a positive reaction with the bismuth test, that with phenyl-hydrazin a comparatively soluble osazone is formed, and that no marked fermentation is produced by yeast. Absolute certainty is only to be obtained by the isolation of lactose. Lactose, like glucose, is dextro-rotatory.

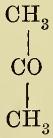
Other sugars of the hexose class, such as lævulose, laiose and isomaltose, have been detected in urine, but are not of any special clinical interest, nor is it necessary to speak here of inosite, which has been found in the urine in cases of diabetes insipidus.

Pentose (optically active or inactive arabinose), which was first detected by Salkowski in the urine of patients addicted to the morphia habit, may even occur in normal urine, a fact which von Jaksch is inclined to attribute to the presence of pentose in beer. It has also been found in the urine of diabetics. Urines containing pentose reduce Fehling's solution and yield osazones with phenyl-hydrazin, but do not give the fermentation test.

The most satisfactory test for pentose is the following (Bial's test):—3-5 c.c. of urine is heated with twice its volume of orcin-reagent, which consists of 500 c.c. concentrated hydrochloric acid, 1 grm. orcin, 20-30 drops of a 10 per cent solution of ferric chloride. As soon as the liquid begins to boil a greenish-blue colour appears, which becomes intensified on standing. The pigment may be extracted with amyl-alcohol, and the amylic extract shows an absorption band between the C and D lines. Glycuronic acid yields a violet amylic extract, which, however, shows a similar absorption band.

IX. Acetone, Aceto-Acetic Acid (Diacetic Acid), and β Oxybutyric Acid

The three substances are closely allied in their origin in the body, and are all apt to be present in considerable quantities in the urine of patients suffering from the graver forms of *diabetes mellitus.* Clinically their abundant presence is found to be a frequent precursor of diabetic coma, and there is good reason to believe that the accumulation of β oxybutyric acid in the blood is the actual cause of diabetic coma. It is further probable that it is simply in virtue of the acid properties of this substance that this effect is produced. It is a fact which has important practical bearings that their production is favoured by the elimination of carbohydrates from the diet of the patients.

Acetone,  $\begin{array}{c}CH_3\\ |\\ CO\\ |\\ CH_3\end{array}$ the lowest member of the ketone series, has been shown by von Jaksch and others to be present in small amount (up to 0·01 grm. in the twenty-four hours) in normal urine. It has usually been held that it is a product of the breaking down of the proteids, both of the food and of the tissues, for it appears in the urine in markedly increased amount during fasting and when carbohydrates are withdrawn from the diet, only to reappear when they are again taken in sufficient quantities. Hirschfield maintains, indeed, that except in grave cases of diabetes the increased excretion of acetone observed under normal conditions is dependent upon dietary causes. Von Jaksch, to whose labours we owe much of the knowledge which we possess of acetonuria, distinguishes the following varieties of pathological acetonuria:—A febrile acetonuria, that occurring in diabetes; acetonuria in certain forms of carcinoma which had not yet produced cachexia; acetonuria due to inanition, and to auto-intoxication.

The excretion of acetone in severe cases of diabetes may reach as high a figure as 5 grammes in the twenty-four hours, and is not dependent upon the amount of sugar; nor does it run parallel with the nitrogenous excretion. When present in such large amounts its characteristic odour is noticed both in the urine and in the breath of the patient.

In fevers some degree of acetonuria is an almost constant phenomenon, and it would appear that acetone is more apt to be formed by children than by adults. In pneumonia it is usually present, but it may be stated generally that febrile acetonuria is dependent rather upon the persistent high temperature than upon the nature of the disease to which the febrile disturbance is due. Hence this form has no important diagnostic significance. The presence of acetone may sometimes be detected in the urine as such, but it is usually necessary to obtain a more concentrated solution by distillation, and to test the distillate. A considerable proportion of the acetone present comes over in the first portion of the distillate. It is important to note that aceto-acetic acid becomes decomposed in the process of distillation with the formation of acetone, and that when this acid is present a considerably larger amount of acetone may be present in the distillate than in the original urine.

The test most usually employed is that of Lieben, which consists in the addition to several c.c. of the urine or distillate of a few drops of liquor potassæ and of a solution of iodine with iodide of potassium. If acetone be present a yellow crystalline precipitate of iodoform is produced, which is seen under the microscope to consist of yellow six-sided tables or stellate crystals. This test is a very delicate one, but it is also yielded, although less readily, by alcohol.

Legal's test depends upon the fact that acetone colours a freshly-prepared solution of sodium nitro-prusside ruby-red in the presence of sodium-hydroxide, the colour quickly changing to yellow. On the addition of excess of acetic acid a carmine tint appears which, in the course of time, changes to violet and finally to blue.

Aceto-acetic acid, or di-acetic acid, $CH_3.CO.CH_2.COOH$, is not a normal urinary constituent, but it is met with in various conditions in which an increased excretion of acetone is apt to occur. Thus it appears when healthy persons are put upon an exclusively meat diet, and in fasting. It is also met with in severe cases of febrile disorders of various kinds, especially in children. Its chief clinical importance is in connection with grave cases of diabetes.

The presence of aceto-acetic acid may be detected by means of the well-known iron reaction of diabetic urine, viz., the appearance of a deep red-brown colour when ferric chloride solution is allowed to fall into the urine drop by drop. If the reaction is obscured by a precipitate of phosphates this may be filtered off, and more ferric chloride may be added to the filtrate, which will acquire a claret-red colour.

Aceto-acetic acid is decomposed when the urine is kept or boiled, and is also decomposed by distillation with the formation of acetone.

β Oxybutyric acid, $CH_3.CH(OH).CH_2.COOH$, is met with in large amounts in the urine in some severe cases of diabetes mellitus, and its production is favoured by a change from a mixed to a strictly carbohydrate-free diet. In some cases the quantities found in the urine have been very large, amounting in two cases examined by Külz to as much as 100 and 223 grammes in the twenty-four hours. More often such smaller quantities as 15-20 grammes are met with.

It is to the formation of this acid that the greatly increased excretion of ammonia by some diabetic patients is ascribed, and it is believed to play the chief part in the causation of diabetic coma. When it is present in the urine aceto-acetic acid is also found.

In addition to cases of diabetes, β oxybutyric acid has been found in smaller amounts in the urine of patients suffering from scarlatina and measles, and by Klemperer in some cases of coma associated with malignant growths.

There is no easy clinical test for the presence of β oxybutyric acid, but its presence in diabetic urine is rendered highly probable, when, after destruction of the contained sugar by fermentation, the urine exerts a marked lævorotatory action upon the polarised ray.

X. Aromatic Substances in Urine

Ethereal Sulphates.—A number of aromatic substances appear in the urine in combination with sulphuric acid in the form of ethereal sulphates. Among these may be mentioned phenol and kresol, pyrocatechin and hydroquinone, which last appears in cases of carbolic acid poisoning, and it is the presence of hydroquinone which gives to carboluric urine the property of darkening when it is exposed to the air. Indoxyl and skatoxyl are also excreted as ethereal sulphates.

The amount of the ethereal sulphates may be increased by the administration of aromatic substances, and it is the fact that in carbolic acid poisoning the phenol present in the urine is combined with sulphuric acid that prevents the obtaining of the colour reaction of phenol with ferric chloride.

The above phenol derivatives are also produced within the body by the bacterial decomposition of albuminous substances in the intestine and elsewhere, and hence the amount of ethereal sulphates excreted affords a valuable indication of the extent of the decomposition processes at work.

An increase of aromatic sulphates is naturally associated with a diminution of the simple sulphates, and accordingly marked fluctuations are observed in the ratio between them, which under normal conditions is roughly 1 : 10, but which in consequence of excessive intestinal decomposition may be greatly reduced. The actual amounts of simple and ethereal sulphates excreted affords an even more valuable criterion, but it must be remembered that even in health both the relative and actual quantities are subject to somewhat wide variation.

As might be expected, the quantity of the aromatic sulphates is markedly diminished by a diet poor in proteids, and also after the administration of certain drugs which act as intestinal antiseptics, and diminish the activity of the intestinal bacteria.

In estimating the quantities of simple and ethereal sulphates respectively, advantage is taken of the fact that the latter are not precipitated by barium chloride, but that after they have been split up by boiling with hydrochloric acid their sulphuric acid is so precipitated. It is best to take two measured specimens from the urine of twenty-four hours and to heat one with hydrochloric acid, and afterwards to precipitate the sulphuric acid from both specimens by means of barium. In order to prevent the precipitation of phosphate the untreated urine should be acidified with acetic acid before the addition of the barium salt. The precipitate is collected, washed, dried and combusted, and in this way an estimate is obtained of the total sulphuric acid in one specimen, and of the simple sulphuric acid in the other. By subtraction of the latter from the former the amount of sulphuric acid in combination with aromatic substances is obtained.

Conjugated Glycuronates.—Aromatic substances, as well as others, such as chloral and morphine, are also excreted as conjugated glycuronates. Glycuronic acid is closely related to glucose, from which it is formed by the oxidation of its alcoholic group, the aldehyde group remaining intact. The acid itself is dextrorotatory, but its conjugated derivatives rotate the polarised ray to the left, and reduce Fehling's solution with varying degrees of intensity. The appearance of more than traces of glycuronic acid in urine is usually associated with the administration of substances which form with it conjugated glycuronates, but some indoxyl is also excreted in such a form. It is by many regarded as an intermediate product of carbohydrate metabolism. Its presence may be suspected in urines which reduce Fehling's solution, are lævorotatory, and do not ferment, and it may be detected by means of Bial's orcin test (for pentose), provided that the mixture of reagent and urine is boiled for a short time.

Indicanuria.—The parent substance of the indoxyl compounds in urine is indol, which is a product of the bacterial putrefaction of albuminous substances. Thus indol is formed in the human intestine in small quantities even in health, and the quantity is larger on a diet rich in proteids. The indol absorbed from the intestine is oxidised to indoxyl in the tissues, and is excreted in the urine for the most part in conjugation with sulphuric acid as indoxyl-sulphate of potassium, and also in part as indoxyl-glycuronic acid. The so-called "indican" of urine is an indoxyl-sulphate, and must be distinguished from the true indican, which is a glucoside met with in indigo-yielding plants.

Urines rich in indican often have a dark brown colour which is not due to the indoxyl sulphate, which is colourless, but, according to Baumann and Brieger, to higher oxidation products of indol. This cause of a dark brown colour must be borne in mind when one is called upon to investigate urine possessing such a tint, and is not so familiar as it should be.

The detection of indican by several methods is easy. Thus a specimen of urine may be boiled with an equal quantity of hydrochloric acid and a few drops of a solution of bleaching powder (Jaffe's test), when indigo-blue and its isomer indigo-red are formed. The liquid may then be shaken with chloroform, as suggested by Stokvis, and as a further evidence, the spectrum of the blue or purple chloroform extract may be examined by the spectroscope as recommended by MacMunn, when the band in red of indigo-blue is seen and a second band near the D line.

A drop or two of nitric acid may be substituted for the bleaching powder (Weber's test), but excess must be carefully avoided lest the indigo formed should be further oxidised to isatin.

Bile pigments if present should be precipitated by basic lead acetate. When the urine contains iodides iodine will be set free which gives a purple colour to chloroform, and which may also interfere with the test by oxidising the indigo pigments.

It should also be mentioned that after the administration of thymol the urine gives, under such treatment, a bluish green colour reaction.

The residue obtained on evaporating the chloroform extract may be treated with alcohol which dissolves indigo-red but not indigo-blue. The washed indigo-blue may then be redissolved in chloroform, and yields a beautiful blue solution.

Various methods for the estimation of indican have been devised, but these do not call for description in this place.

The precipitation of amorphous or crystalline indigo pigments from urine, and the occasional formation of indigo calculi, will be referred to later.

The clinical significance of the presence of large amounts of indigo in urine is due to the evidence which it affords of excessive proteid decomposition under the influence of bacteria, either in the intestinal canal or in some of the body cavities. The most frequent cause is excessive albuminous decomposition in the alimentary canal, which is the seat of origin of the indoxyl-sulphuric acid present in normal urine. A quantitative estimate of such changes is best obtained by the determination of the relation between the aromatic and ordinary sulphates of the urine.

Thus an increased output of indigo is often observed in cases of intestinal obstruction and in not a few intestinal disorders. Simon lays much stress upon a diminished secretion of hydrochloric acid by the stomach as a cause of indicanuria. Thus it occurs in many cases of carcinoma of that organ, and also in connection with gastritis.

Examples of excessive formation of indol elsewhere than in the alimentary tract are afforded by cases of putrid empyema, fœtid bronchitis, and pulmonary gangrene, and von Jaksch attaches much importance to such varieties of indicanuria. He also includes peritonitis in this group, but in this condition the associated paralysis of the intestinal walls may also contribute to the result.

The precipitation of free indigo from the urine has no special clinical significance, but a large precipitation is indicative of an excessive output of the indigo-yielding materials, especially of indoxyl-glycuronic acid. The separation is usually determined by putrefactive changes in the urine itself.

Skatoxyl compounds also yield red colouring matters under the influence of acids with an oxidising agent, and it is probable that such skatoxyl derivatives are often produced together with the indigo pigments when the urine is subjected to Jaffe's test.

Alkaptonuria is the name assigned by Boedeker to a condition of great interest, and at the same time of extreme rarity. The urine, which has a natural appearance when passed, darkens on exposure to air, passing through various shades of brown to black. This change is much more rapid when the urine is rendered alkaline. The urine also stains linen or woollen fabrics deeply, and readily reduces Fehling's solution with the aid of heat. However, it does not give the bismuth test for sugar, and the reducing substance contained in it does not ferment with yeast and does not rotate the polarised ray in either direction.

By these means, and by the rapid darkening with alkalies, the condition is recognised, and its nature may be proved by the isolation from the urine of homogentisic acid in the form of the lead salt.

Alkaptonuria is in most instances congenital, life-long, and harmless, but has been temporary, or has developed some time after birth, in a few cases. Of the congenital cases a considerable number have occurred in brothers and sisters of whom a large proportion have been the children of first cousins. It has been much more frequently met with in males than in females.

The anomaly usually comes under notice on account of the manner in which the napkins of infants are stained by their urine, or in adult life on account of the refusal of the patients by insurance offices because of the reducing power of their urine.

In some of the earlier cases the peculiarity was attributed to pyrocatechin or to protocatechuic acid, but there is every reason to believe that homogentisic acid (hydroquinone-acetic acid, $C_6H_3(OH)_2.CH_2COOH$) is the abnormal constituent in all true alkapton urines. Since the discovery of this acid by Wolkow and Baumann it has been found in every case examined. A second allied acid, uroleucic, which was detected in association with homogentisic acid in the urine of two brothers studied by Kirk, has not since been met with.

As Wolkow and Baumann first showed, the output of homogentisic acid in such cases is conspicuously increased by a diet rich in proteid, and still more by the administration of tyrosin by the mouth, and there is little doubt that tyrosin, formed in the intestine, is its parent substance. On the other hand, when tyrosin is given to normal individuals no alkaptonuria results.

The evidence available suggests that alkaptonuria is a "sport" of metabolism, a chemical analogue of structural malformations, but wherein the metabolism of alkaptonuric persons differs from that of normal individuals, and why they excrete intact the benzene ring of their tyrosin, which, under ordinary circumstances, is broken up in the tissues, is not yet apparent.

The problem is rendered more difficult by the fact that the change from tyrosin to homogentisic acid involves chemical changes of a quite unfamiliar kind. Wolkow and Baumann suggested that this change might be brought about by a special micro-organism in the intestine, but further researches have not lent support to such an infective theory, which can hardly be reconciled with the known facts.

The recognition of alkaptonuria as a harmless condition is of some importance from a clinical point of view and in connection with life insurance, but there can be no doubt that its rarity is real and not apparent. The total of cases recorded up to the present time is only forty, and of these no less than eighteen have occurred in seven families.

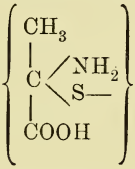
XI. THE NEUTRAL SULPHUR OF URINE, HYDROTHIONURIA, CYSTINURIA

Some 15 per cent of the total sulphur in human urine has escaped oxidation to sulphuric acid, and for this fraction Salkowsky suggested the name of neutral sulphur. The forms of combination in which the neutral sulphur exists is not fully known, but, as Lépine has shown, some of it is much more readily oxidisable than the rest. Some is certainly in the form of sulphocyanides and some of cystein, which, as Baumann has shown, is present even in normal urine. Some is almost certainly derived from the taurin of bile, for in cases of obstruction of the bile-ducts the total neutral sulphur is increased, whereas in dogs with biliary fistulæ it is diminished. In the rare condition known as cystinuria the excretion of neutral sulphur is naturally above the normal.

Hydrothionuria.—The occurrence of sulphuretted hydrogen in the urine is usually due to bacterial decomposition, either within or without the body, and the amount produced by such decomposition will naturally be greater when the neutral sulphur is increased, as in cases of cystinuria. More than one species of bacterion appear to have the power of bringing about such decomposition in urine. Another cause of hydrothionuria is the existence of a fistulous communication between the colon and the urinary apparatus, and according to Betz the gas may find its way by transfusion without the existence of any fistulous opening.

For the detection of sulphuretted hydrogen the urine is placed in a flask, and a paper moistened with a solution of lead acetate and a drop of sodium hydrate solution is held in the neck of the flask by means of the cork. If sulphuretted hydrogen is being evolved the paper becomes blackened. Considerable quantities of the gas may be recognised by its characteristic odour.

Cystinuria.—It has already been mentioned that a substance closely allied to cystin, viz. cystein, is present in traces in normal urine; but in an extremely rare condition, of which, however, more than a hundred cases are on record, considerable quantities of cystin are passed in the urine, in which it may form a sediment of colourless hexagonal crystals, or may constitute calculi of greater or less size.

Cystin  $\left\{\begin{array}{l} CH_3 \\ | \\ C\begin{array}{l} / NH_2 \\ \backslash S- \end{array} \\ | \\ COOH \end{array}\right\}$ 2, is in all probability an intermediate product of proteid metabolism, which, under normal conditions, undergoes further oxidation, its sulphur appearing in the urine in the form of sulphates. In cystinuria the neutral sulphur is increased both in absolute amount and relatively to the sulphates. Quite recently it has been shown by Mörner and Ebden that cystin may be readily obtained by the hydrolysis of proteid substances.

Cystinuria, although an anomaly of peculiar pathological interest, acquires its only clinical importance from the tendency of the cystin precipitated from the urine to form calculi; but the urine may deposit crystals of cystin, at least over long periods, without any calculi being formed. On the other hand, small calculi may be passed or may be formed in rapid succession.

Of great interest is the occurrence, in association with cystinuria, of the diamines putrescine and cadaverine in the urine and fæces of the patients, a fact which led Baumann and Udranszky to suggest that as these are well-known bacterial products, cystinuria itself might be indirectly of bacterial origin.

Against this we have the great tendency for cystinuria to occur in several members of a family, and the fact that it may be inherited from either parent. Moreover, the early age at which cystin calculi have occurred in not a few instances suggests that it is probably a congenital anomaly. The analogies here presented with alkaptonuria, although the chemical errors in the two conditions are entirely different in character, strongly suggest that the two conditions have something in common, and that in cystinuria we have a second example of a chemical malformation.

XII. Lipuria and Chyluria. Cholesterin in Urine

Lipuria.—Fat may present various appearances when present in the urine. When abundant it may form oily drops which float upon the surface of the liquid, and which when sucked up by a piece of filter paper produce greasy marks upon it. In other cases it appears as a cloud consisting of small droplets suspended in the urine, as in some cases of fracture of bones; or again as an evenly diffused emulsion, which gives to the liquid a milky appearance, as in chyluria. Most frequently its presence is only revealed by the microscope in the form of minute highly-refractive globules, which are usually adherent to renal casts or enclosed in degenerated epithelial cells. Lastly, the very rare urinary calculi known as urostealiths contain a large proportion of fat.

When fat is present in minute amount in a sediment it may be recognised by staining with osmic acid, but larger quantities may be removed by shaking the urine with ether and submitting the residue left after evaporation of the ether to the ordinary tests for fats.

Cases of lipuria or apparent lipuria admit of classification into four main groups, viz.:—

(1) Those in which the fat has been accidentally or intentionally added; (2) those in which the blood contains an undue amount of fat which is excreted by the kidneys; (3) those in which the fat is derived from degenerative changes in the kidneys themselves, or in some lower portion of the urinary tract; and (4) cases of chyluria, which condition calls for special discussion.

It is of great importance to exclude accidental contamination caused by the use of an oiled catheter, or the addition of milk or oil to the urine after it has been passed. Cases in which the fat is abundantly present will only repay further investigation after the exclusion of such causes.

Normal human urine contains no fat, but it has been found under conditions which may fairly be regarded as physiological, as, for example, during pregnancy, and also after the administration of oils, such as castor-, cod-liver- or olive-oil, for medicinal purposes.

In *diabetes mellitus* the abundant presence of fat in the blood, which is a common phenomenon, may be accompanied by lipuria, and a like result may follow from a like cause in other diseases, attended by conspicuous wasting, such as *phthisis pulmonalis.* In acute yellow atrophy of the liver also, and in phosphorus poisoning, fat may find its way into the urine.

Of special interest is the lipuria which sometimes follows fractures, especially of long bones, and which is attributed to the entrance of medullary fat into the circulation. It may be met with after the operation of osteotomy, as well as after accidental fractures, and such lipuria is temporary and may be intermittent

In chronic parenchymatous nephritis fattily degenerated epithelial cells and fatty casts are often found, and their presence indicates a marked degree of degeneration of the renal epithelium. Simple fatty degeneration of the kidneys may also be attended by fat in the urine, and among other diseases of the urinary tract which may give rise to lipuria pyelitis, abscesses rupturing into the urinary passages, and malignant growths may be mentioned.

Chyluria.—In chyluria the urine has the appearance of milk, but may have a pink tint from admixture of blood, or may deposit a scanty red sediment of blood corpuscles. The opacity is due to the presence of fat, which may be removed by shaking with ether, when the urine is left clear. The suspended fat is in the finest possible state of division, and the microscopic appearances are best imitated by adding condensed rather than fresh milk to the urine. Albumin is present as well as fat, albumoses have also been found in chylous urine, and in some cases sufficient fibrin is present to form coagula, or to cause the solidification of the whole into a mass like *blanc-mange*, which, after a time, again liquefies. Occasionally such coagulation occurs in the bladder with distressing results.

The microscope shows red corpuscles and leucocytes, but the absence of renal elements points to the absence of any serious implication of the kidneys. The essential cause of chyluria appears to be the direct opening of a lymphatic channel into some part of the urinary passages, an explanation which best accords with the very intermittent character of the phenomenon, for, in the course of a single day chylous urine may be passed at one time and normal at another.

In the great majority of instances the cause of chyluria is the *filaria sanguinis hominis*, the mechanism being the obstruction of a lymph channel by the parent worm or by the ova, the distension of the vessel behind the obstruction and its rupture into the urinary passages, with a resultant intermittent flow of chyle into the urine. However, there appear to be some cases which are definitely not of this nature, and in which the admixture of chyle is due to some other cause than the filaria.

Cholesterin in Urine.—This will be the most convenient place to consider the occurrence of cholesterin in the urine. Its presence indicates disease of the urinary apparatus, and there is no satisfactory evidence that it is excreted by the kidneys as a product of metabolism. The traces found in cases of fatty kidney may be attributed to the fatty casts and débris which the urine contains, and in which the cholesterin is probably held in solution in the fat.

In the rare cases in which it forms a crystalline urinary sediment, it is derived from degenerated urinary epithelium, or the rupture into the urinary passages of cysts containing cholesterin. Thus it may appear in cases of hydronephrosis, of congenital cystic disease of the kidneys, and in connection with chronic cystitis and fatty degeneration in the bladder-walls.

Calculi containing cholesterin have been met with. In some instances they have obviously been facetted gall-stones, which have found their way along fistulous channels, but such an explanation will not apply in all instances (see section "Urinary Calculi," p. 132).

XIII. Pigments

The yellow colour of normal urine is entirely or almost entirely due to urochrome, but although there is good reason to believe that, apart from the effects of dilution and concentration, the excretion of this pigment is subject to marked variations, such variations do not as yet come within the scope of clinical medicine. This is largely due to the facts that urochrome yields no characteristic spectrum, and that we have not as yet any means of estimating its amount. It will here suffice to say that this pigment is in all probability derived from hæmoglobin, and that its formation is apparently independent of any processes which go on in the alimentary canal.

Urobilin, unlike urochrome, yields a very conspicuous absorption band which allows of its ready detection in urine, and it is not difficult to estimate, at least roughly, the amount which is present in any given specimen. It is largely excreted in the form of an unstable chromogen which is readily converted, by oxidation, into the formed pigment.

Urines rich in urobilin, and in which the colour of this substance is not obscured by other pigments, exhibit a peculiarly rich orange tint, and when examined in a conical glass show a tinge of pink near the apex of the cone. When examined with the spectroscope they show a broad and intense absorption band near the F line, which becomes broader and darker as deeper layers of urine are examined. Urobilin is precipitated by saturating the urine with ammonium sulphate, and solutions of the pigment in alkalies yield a brilliant green fluorescence, and a shifting of the band towards the red, on the addition of zinc chloride. This is best seen when alcoholic solutions are employed. For clinical purposes the direct spectroscopic examination of thin layers of urine will usually suffice for its detection, but when the violet end of the spectrum is much obscured by other pigments it may be necessary to precipitate it in the manner referrred to, or to extract it with amylic alcohol, after the addition of a small quantity of acetic acid to the urine. The amylic extract may show the bands of hæmatoporphyrin and of uroerythrin in addition to that of urobilin.

The evidence forthcoming points to the formation of urobilin in the alimentary canal by the action of micro-organisms upon the bile pigment, for it can be shown that when bile ceases to enter the alimentary canal urobilin is no longer formed, and that it disappears from the urine as well as from the fæces, in which latter it is normally present in far larger amounts, mostly in the form of chromogen. There are, on the other hand, some observations recorded which make one hesitate to assert too positively that urobilin never has a more direct origin from the blood pigment.

If the above view be correct, it is obvious that an increase of urobilin in the urine may be indirectly due to increased hæmolysis, the abnormal destruction of hæmoglobin being followed by an increased output of bilirubin, the material from which urobilin is formed. Variations in the excretion may also be due to increased activity of the bacterial processes in the intestine, to the rate of passage of the intestinal contents along the canal, and to such conditions as altered reaction of the contents, and the relative amounts of bilirubin and biliverdin in the bile.

Thus the conditions which determine an increased or diminished output of urobilin are complex, and often difficult to unravel, and it is easy to understand why, in spite of the large amount of research which has been expended upon this subject, the results afford so little that is of real clinical value. This much is certain, that when a urine shows a conspicuous urobilin band there is some distinct deviation from the normal. Nor is the occurrence of urobilinuria in connection with active hæmolysis open to doubt, as witness its occurrence in connection with pernicious anæmia, and with the absorption of large quantities of extravasated blood.

In diseases of the liver there is usually persistent urobilinuria, a fact which raises the chief difficulty in connection with the theory of its intestinal origin. It has been suggested that the diseased liver loses a power which it otherwise possesses of destroying a large proportion of the urobilin absorbed from the intestine, or, on the other hand, that the hepatic disease affects the quality of the bile and the readiness with which the contained pigment is converted into urobilin.

In many febrile conditions also there is a conspicuously increased excretion of urobilin and its chromogen.

When the common bile-duct is completely obstructed urobilin and its chromogen disappear from the urine, and the practically complete absence of this pigment from the fæces in such cases affords very valuable evidence of such occlusion. Thus in two cases of equally intense jaundice the fact that the duct is completely occluded in the one and not in the other may be readily ascertained by this means. However, a trace of urobilin usually persists in the fæces, which trace is probably formed from bilirubin which makes its way through the intestinal walls.

Diseases of the kidneys often lead to diminution, or absence of urobilin from the urine, probably as the result of diminished permeability of these organs.

Uroerythrin.—The presence of this pigment is easily recognised when urate sediments are thrown down, and many of the palest of such sediments show the characteristic pink tint when filtered off. The most intensely pink sediments are met with in connection with disorders of the liver, such as cirrhosis, and in the passive congestion secondary to heart disease. Uroerythrin is also excreted in comparatively large quantities in certain febrile disorders, such as acute rheumatism and pneumonia, and also in gout. In typhoid fever, on the other hand, this is not usually the case.

If, as seems highly probable, the excretion of uroerythrin is always indicative of hepatic disorder, it is clear that not only actual disease of the liver but even very slight functional disturbances, such as may result from indiscretions of diet, or may attend upon attacks of dyspepsia, are sufficient to cause it to appear even in the urine of apparently healthy persons. It may be mentioned that in cases of cirrhosis Riva has observed a marked diminution in the output of uroerythrin when the patients were put upon a milk diet.

The pink colour of urate sediments when present, and the dark absorption band near the D line which such sediments show when examined with the spectroscope by reflected light, suffice for the recognition of its presence. When in solution in large amount it imparts to the urine a fiery orange colour, and on the addition of caustic potash the colour becomes much paler and shows a greenish tint. From such urine, slightly acidified with acetic acid, the pigment is readily taken up by amylic alcohol, to which it gives a similar colour, and before the spectroscope the feeble complex band in the green, characteristic of this pigment, may usually be recognised, together with the absorption bands of hæmatoporphyrin and of urobilin. Indeed this method, suggested by Riva and Zoja, affords the readiest means of detecting the presence of all three pigments when they are present in more than minute traces.

Hæmatoporphyrinuria forms the subject of a special article, and it is here only necessary to repeat that hæmatoporphyrin occasionally appears in greatly increased quantity, together with other little known abnormal pigments, in the urine of patients who have been treated with sulphonal or allied drugs, and much more rarely apart from this cause. Such urines have a deep port-wine colour.

In morbid urines there is often much more than the normal trace of this pigment, but not enough to appreciably affect the colour. Such increase can in most instances be traced to disorders of the liver, functional or organic, and even in rheumatic fever it is not improbably due to a secondary affection of that organ.

The evidence forthcoming all tends to show that an increased excretion of hæmatoporphyrin affords no evidence of excessive hæmolysis, but rather of a perverted metabolism of the blood pigment. Hæmatoporphyrin is also found in traces in normal bile and fæces and in larger amount in the meconium of new-born infants.

Melanuria.—Patients who are the subjects of melanotic growths occasionally pass urine which is of natural colour when freshly passed, but which soon darkens on exposure to air and in time becomes quite black. More rarely the urine is very dark in colour even when passed. This condition is readily distinguished from others in which the urine turns brown or black by certain characteristic tests which are of easy clinical application. Thus the blackness is promptly developed when nitric acid is added to the urine, and an intense blackening is also observed on the addition of ferric chloride. Lastly, bromine water yields a copious precipitate which quickly takes a chocolate hue, but this reaction is less delicate than those abovementioned, and may fail when the melanogen is scanty in amount.

Such urines also usually yield Thörmalen's reaction, namely, a deep blue colour, with sodium nitroprusside, potassium hydrate and acetic acid, but this is apparently due to some other constituent than the melanogen present. The chromogen, melanogen, has not yet been isolated, but the formed pigment, which has been studied by Mörner, appears to be of the same nature as that of melanotic growths.

It is often stated that melanuria is not confined to cases of melanotic growths, but may also occur in connection with other forms of malignant tumour, and in wasting diseases. When, however, the accounts of the cases on which this statement is based are referred to the evidence of true melanuria is found to be by no means conclusive, and some of them at least appear to have been examples of the very dark brown urine which accompanies a large excretion of indican. There is, indeed, good reason to believe that true melanuria is only met with in cases of melanotic sarcoma, and even in such cases it is not always present. I have never met with it in cases in which the growth was still limited to its primary seat, but only when the liver and other organs have become secondarily involved. Even in such cases the amount of melanogen present may be small, and the darkening of the urine may fail to attract attention.

The diagnostic value of this symptom is considerably impaired by the fact that in most cases before melanuria develops the patient is well known to be suffering from a melanotic growth.

XIV. Bile-Pigment and Acids

The bile-pigment may find its way into the urine in two distinct ways. In almost every instance its presence is one of the phenomena of jaundice, and is associated with coloration of the skin and conjunctivæ. Very rarely it results from the existence of a fistulous opening connecting the biliary and urinary passages, and in some such cases the presence of bile in the urine has been associated with the passage of gall-stones per urethram. Seeing that such choluria is as a rule unattended by jaundice it affords valuable evidence of the existence of a fistulous communication.

The colour of the urine suggests the presence of bile-pigment, which in freshly-passed urine usually has the form of bilirubin, but biliverdin and other derivations are apt to be formed when the urine stands in contact with air.

Of the tests employed for the detection of bile-pigment three only need be mentioned here. Maréchal's test is carried out by allowing a dilute tincture of iodine to run on to the surface of the urine in a test-tube. When bilirubin is present a green ring appears at the junction of the liquids owing to its oxidation to biliverdin.

Gmelin's test is best performed by allowing the urine to flow on to the surface of some nitric acid in a test-tube. A coloured ring forms at the junction, and when the tube is gently shaken, so as to bring about some admixture of the liquids, the characteristic play of colours is observed. Seeing that the chromogens of urine tend to yield pink and purple colours with nitric acid, it is necessary that the green tint of biliverdin should be clearly seen, in order that the presence of bile-pigment may be rendered certain.

When the quantity of bilirubin present is scanty, and especially when the indoxyl compounds are at the same time abundant, Gmelin's test may yield equivocal results. In such cases, Huppert's test, although not quite so simple, affords an excellent means of detecting bile pigment. The pigment is precipitated by the addition of milk of lime, and the filtered precipitate, which will be yellow if bile be present, is treated with alcohol to which a few drops of dilute sulphuric acid have been added. On heating a rich green colour is obtained.

The biliary acids, like the pigments, are met with in icteric urines, but their detection hardly comes within the scope of clinical medicine, and, seeing that the more recent investigations have tended to abolish the distinction formerly drawn between what was regarded as hepatogenous and hæmatogenous jaundice, their presence in varying amounts has lost much of the diagnostic significance formerly attached to it. Their presence in traces in normal urine has been asserted and also denied.

It is here only necessary to emphasise the fact that Pettenkofer's test is not directly applicable to urine as other constituents of that liquid yield colour reactions not to be definitely distinguished from that yielded by the bile acids. Hence their satisfactory detection becomes a matter of difficulty and involves their isolation.

Cholesterin is not met with in the urine as a biliary constituent in cases of jaundice; when present it is derived from the kidneys or urinary passages, except in the very rare instances in which gall-stones enter the urinary passages by a fistulous opening.

XV. Pneumaturia

This is the name given to a rare condition in which free undissolved gas is present in the bladder and is passed in bubbles with the urine, occasionally with an audible sound.

Cases of pneumaturia fall into three classes, viz.:—

1. Those in which air has been introduced from without, either in catheterisation or for the purpose of distending the bladder. This variety is clearly of no clinical importance.

2. In some cases a fistulous opening exists between the bowel and the urinary bladder, most commonly in association with malignant growths of the rectum or sigmoid flexure. In such cases the escaping gas has a fæcal odour, and fæcal particles may at times be found mixed with the urine.

3. In the cases of the third class the gas is formed in the bladder itself as a result of bacterial processes. Such formation of free gas is usually met with in cases of diabetes in which the bladder has become infected by one of several kinds of bacteria or yeasts, and the sugar undergoes fermentation with the development of carbon dioxide (see "Bacteriology of Urine").

As the absorption of gases from the bladder takes place somewhat rapidly, a considerable development of gas is necessary in order that the symptom of pneumaturia may be produced.

XVI. Urinary Sediments

The microscopical and chemical investigation of sediments constitutes an important part of the clinical examination of urine. When the sediments are abundant they may be taken up by means of a pipette from the bottom of the urine as it stands in a conical glass, or may be drawn off from a burette in which some of the urine has been placed. When, on the other hand, it is necessary to institute a careful search for structures or casts which may only be present in very small numbers, it is necessary to centrifuge a portion drawn from the lower layers of the liquid after it has stood for some time.

Urinary sediments may be grouped in three main classes:—

1. Unorganised sediments consisting of inorganic salts or organic compounds which have been deposited either in an amorphous or crystalline state.

2. Organised sediments, including cells derived from the blood, from the kidneys, or from the walls of the urogenital tract, and with these it is convenient to include the important structures known as casts, which frequently enclose cellular structures of various kinds.

3. Accidental contaminations which are apt to find their way into the urine, and which, although themselves of no clinical importance, require to be recognised lest they should be mistaken for true urinary deposits.

1. UNORGANISED SEDIMENTS.—Of the sediments belonging to the first of these groups some are extremely common, and are met with every day, others are seldom seen, and others again are so extremely rare that from a practical point of view they amount to little more than clinical curiosities. Of most of the sediments in question it will only be necessary to give a brief description in this place, seeing that their significance has been dealt with in the more chemical portions of the present article.

Amorphous Urates.—These are the commonest of all the sediments met with in urine. They consist of a mixture of uric acid salts, including those of sodium, potassium, calcium, and magnesium, and especially those of the two first named metals. It has been usually held that they consist of the so-called quadriurates, formed by the combination of a molecule of biurate with a molecule of free uric acid, and the ease with which their aqueous solutions throw down crystals of free acid is ascribed to the disintegration of the compound molecule. However, much doubt has recently been thrown upon the accepted views on this matter. Under the microscope the sediment is seen to consist of minute amorphous granules mostly grouped into threads and clusters.

Such sediments are deposited from acid urines on cooling, and their nature is easily recognised by the readiness with which they dissolve when the urine is again warmed. Their colour, which varies from a pale yellow, through brick-red, to a brilliant pink, is due to urinary pigments which they carry down with them. The chief of these are urochrome, which is always present in them, and which imparts a yellow tint even to the palest sediments, and uroerythrin, which has a special affinity for uric acid and the urates, and which probably enters into some sort of combination with them, for the colour of the pink sediments, and their spectrum as seen by reflected light, differs from those of the isolated pigment.

The frequency of the pink sediments is due to the fact that the same morbid conditions are wont to determine the formation of uratic deposits and the excretion of large quantities of uroerythrin.

As might be expected, urate sediments are commoner in winter than in summer, and they are met with in the urine of healthy persons after active muscular exertion or after slight indiscretions of diet. The chief factors which determine their occurrence are concentration of the particular specimen of urine and the degree of its acidity. They do not necessarily afford an indication of excessive output of uric acid, although such increase may contribute to their formation. They are apt to occur in the course of most febrile disorders, and deep pink sediments are specially frequent in connection with organic and functional disorders of the liver, as also in connection with gouty troubles, and in cases of acute rheumatism.

The disappearance of such sediments when the urine is warmed, and their coloration, usually leave no doubt as to their nature, but if further confirmation is needed this may be readily obtained by filtering off the sediment and applying the murexide test, or by dissolving it in water and observing the separation of crystals of uric acid after the addition of a small quantity of hydrochloric acid.

Ammonium biurate is occasionally deposited from ammoniacal alkaline urines in the form of minute yellow or brownish spherules which are beset with needle-like excrescences, the so-called hedgehog crystals. If the crystals are dissolved in an acid, uric acid crystals will be deposited from the solution. This deposit is usually met with in association with sediments of ammonio-magnesium and other phosphates.

Uric Acid.—Crystals of free uric acid form a very common urinary sediment. They may form an abundant deposit of deep red "cayenne pepper" sand, or may be scattered as golden crystalline points through a cloud of mucus at the bottom of the urine glass. The crystals vary very greatly in size and in form, but are usually readily recognised by their colours. These colours are due to included urinary pigments, especially urochrome and uroerythrin, but other pigments share in their coloration. When deposited from urine containing bile they are tinted by bilirubin or biliverdin or a mixture of the two, and those deposited from carboluric urine are deep brown in hue and appear black in bulk. Urobilin takes no part in the coloration of these crystals.

In scantily pigmented urines, and especially in that of young children, they may be almost colourless, or actually devoid of colour. The form of the crystals is also profoundly modified by the included colloids, and they always deviate somewhat widely from the form of the rectangular plates of pure uric acid. The predominant shape of the urinary crystals is the canoe or whetstone form, and many of the less usual forms are produced by the fusion of such crystals. Sheaves and rosettes of prismatic crystals are occasionally seen, especially in urines containing biliverdin, and hour-glass and dumb-bell crystals are also described. A double-comb form may also be referred to, which is apt to occur when the precipitation has been brought about by the addition of an acid to the urine, and it should be borne in mind that very faintly tinted hexagonal crystals of uric acid have occasionally been mistaken for those of cystin.

Any urine, if kept acid, will, in course of time, deposit crystals of uric acid, and although an excessive excretion of the acid is one of the factors which favour the formation of such sediments, they are apt to occur apart from this cause in any concentrated and highly acid urine. In early childhood they are very common, and in the urine of infants mats formed by the interlacing of innumerable minute whetstone crystals are often seen, sometimes in association with hæmaturia.

As a rule, uric acid sediments have no great clinical significance, but the frequent appearance of cayenne pepper sand is a common accompaniment of calculus formation.

When the nature of the crystalline deposit is in doubt, owing to scanty pigmentation or for other reasons, the murexide test affords conclusive evidence.

Calcium Oxalate.—Crystalline deposits of calcium oxalate are of frequent occurrence. They are met with both in acid and alkaline urines, especially in the former. The crystals, which are minute, may be deposited upon grease streaks on the sides of the containing vessels, or may form a snow-white cloud upon the surface of a collection of mucus at the bottom of the urine glass. The crystals, which are highly refractive, are as a rule colourless, none of the ordinary urinary pigments being included by them, but when deposited from icteric urines they acquire a feeble yellow or green tint.

The crystals assume several different shapes. The most usual and characteristic of these is an octohedron with a short principal axis, which under the microscope has the appearance of a square envelope, whence they are usually spoken of as envelope crystals. Twin octohedra and other more complex interpenetrating forms are also met with.

Less commonly short, square prisms with pyramidal ends are seen, and in some specimens crystals of this type preponderate.

The so-called dumb-bell crystals are more or less flattened oval plates with deep grooves upon their oval surfaces which render them biconcave. Such crystals sometimes exhibit faint striation, and when seen edge on present the appearance of dumb-bells. They are usually mixed with the ordinary octohedral forms, and in some specimens they are exceedingly abundant.

Cystin.—Sediments of cystin are extremely rarely encountered in acid or faintly alkaline urines, but when present they usually form abundant greyish white deposits. Cystinuric patients often suffer from cystitis. The crystals of which the sediments are composed are colourless hexagonal plates, the sides of which are often of unequal length. Superposed hexagons are also met with. They can hardly be mistaken for any other urinary crystals, with the exception of the pale hexagons of uric acid already referred to.

The crystals are insoluble in water, alcohol and ether, but readily dissolve in ammonia, from which they are redeposited as the ammonia evaporates. The following beautiful test serves for the recognition of cystin. Some of the sediment is dried and placed upon a glass slide, some strong hydrochloric acid is allowed to run under the cover-glass, and, as this comes in contact with the deposit, rapidly growing prismatic crystals grouped in rosettes replace the original hexagonal plates, and these crystals, which consist of a compound of cystin with hydrochloric acid, melt away as rapidly as they were formed when the acid is diluted by running in some water.

Xanthin.—A crystalline sediment of xanthin was met with in one single instance in the urine of a child who had previously suffered from symptoms of renal colic. The sediments consisted of small whetstone-shaped crystals which dissolved readily when the urine was heated. The sediment was soluble in water and in hydrochloric acid, and from solution in the latter was deposited in six-sided tables and prisms. It also dissolved in nitric acid without effervescence, and on evaporating the acid a yellow stain was left. It is possible that such crystals have sometimes been mistaken for colourless or faintly tinted crystals of uric acid.

Phosphatic Sediments.—When any urine is rendered alkaline with a fixed alkali, the earthy phosphates and the normal or mono-hydrogen phosphates of calcium and magnesium are precipitated, and a turbidity due to the same substances is observed in urine which is alkaline when passed. The sediments from such urines are colourless and amorphous, and their nature is easily recognised by the ease with which they dissolve on the addition of acetic acid.

In the urines which are the seat of putrefactive changes, and owe their alkaline reaction to ammonia, there are found, in addition to amorphous phosphates, abundant crystals of ammonio-magnesium phosphate (triple-phosphate), $MgNH_4PO_4.6H_2O$. These crystals, which are amongst the largest met with in urinary sediments, are rhombic prisms, of the so-called coffin-lid form. Similar crystals are also deposited from amphoteric urines apart from any amorphous sediment.

Acid calcium phosphate, $CaHPO_4.2H_2O$, is also thrown down in crystalline form from some amphoteric or faintly acid urines. These crystals, which are usually spoken of as "stellar phosphates," are grouped into stars or rosettes, or appear as isolated crystals, or again in groups of two or three. The individual crystals are long narrow prisms.

Normal magnesium phosphate, $Mg_3(PO_4)_2.22H_2O$, has occasionally been found as a crystalline sediment in the urine of patients with gastric dilatation to whom magnesium carbonate has been freely administered, in the form of oblong, rhombic, highly refractive tables, and Bradshaw has under similar circumstances met with an abundant deposit of long needles which he identified as consisting of acid magnesium phosphate, $MgHPO_4.14H_2O$.

Like amorphous phosphatic sediments, the above crystalline deposits may be readily distinguished from other crystals deposited from urine by the readiness with which they dissolve in acetic acid.

Calcium sulphate has been hitherto found as a crystalline sediment in only three cases: in two instances in urines strongly acid in reaction, in a third in association with triple phosphate and calcium carbonate. Such deposits are insoluble in acids and in ammonia alike. The crystals have the forms of long needles, or of long tables with sloping ends.

Calcium carbonate is seldom deposited from human urine, either in amorphous or crystalline form. It may be met with in association with amorphous phosphates. Occasionally it appears as dumb-bell crystals, which may be mistaken for those of calcium oxalate, or in spherules which show a concentric striation. They may be recognised by the fact that they dissolve in acetic acid with the evolution of carbon dioxide.

Tyrosin and leucin are occasionally met with as sediments in the urine of patients suffering from acute yellow atrophy of the liver or phosphorus poisoning. Tyrosin appears as fine needles arranged in sheaves or rosettes, which may be either colourless or pigmented. Leucin, which usually occurs in urine in association with tyrosin, is rarely if ever deposited from the urine direct, but on evaporation it sometimes appears in the form of greenish yellow spheroids which exhibit radial and concentric striation.

Hippuric acid has very seldom been seen as a sediment, consisting of rhombic prisms. Its appearance has usually followed the administration of benzoic acid or the eating of certain fruits.

Indigo.—Urines which are undergoing alkaline fermentation frequently deposit indigo-red and blue, either in the form of amorphous particles or as acicular crystals arranged in rosettes. Such urines often exhibit a blue scum upon the surface. The masses or crystals of indigo blue have a dark blue colour, whereas those of indigo red are of a violet-red hue. The free pigment is in such cases formed by the decomposition of indoxyl-glycuronic acid, the less abundant of the indoxyl compounds met with in urine.

Bilirubin is occasionally met with as a crystalline or amorphous deposit in jaundiced urine. The crystals are yellow or brown rhombic tables or needles arranged in tufts or rosettes, indistinguishable from those of *hæmatoidin*, which are sometimes met with in connection with diseases of the kidneys and urinary passages, and perhaps with special frequency in cases of malignant growths. It is highly probable that bilirubin and hæmatoidin are chemically identical.

Cholesterin, when present as a crystalline sediment, appears to be always derived from the kidneys or urinary passages, as in cases of hydronephrosis and chronic cystitis, or from cysts communicating with the passages. The crystals which may form an abundant deposit have the well-known characteristic form.

Soaps.—Von Jaksch has met with crystals which might easily be mistaken for those of tyrosin, but which are shown by their solubilities and reactions to be of some other nature. From their behaviour with solvents he is inclined to regard them as consisting of the calcium and magnesium soaps of higher fatty acids.

(2) ORGANISED SEDIMENTS.—*Red blood corpuscles* are present in the urine in every case of hæmaturia. In many instances they have lost their biconcave form, and have been to a great extent deprived of their hæmoglobin. Not infrequently they have become crenate. Their presence is of great importance in distinguishing between hæmoglobinuria and hæmaturia, and affords evidence of morbid conditions either in or below the kidneys.

Leucocytes are very frequently present in small numbers in the urine under a variety of morbid conditions, and in females their occurrence in larger numbers may be due to admixture of vaginal discharges. When pus has become mixed with the urine the number of leucocytes is often very large indeed. Their appearance is to a great extent dependent upon the reaction of the liquid in which they are suspended, and in alkaline urines their recognition may present some difficulty from swelling and opacity of the cells.

The clinical significance of the presence of leucocytes is largely dependent upon their numbers, and upon the association with them of other cells or renal casts.

Spermatozoa may be found in the urine of men after seminal emissions, and they may be readily recognised by their long, thread-like processes and by the characteristic form of their heads. Except in very fresh specimens their mobility is lost. Some expression of semen may occur in cases of obstinate constipation as the result of pressure upon the *vesiculæ seminales*, and it is also found in urine passed after an epileptic fit.

Bacteria of various kinds may often be found in the sediments, but the question of the bacteriology of the urine will be considered in a separate article (p. 137).

Epithelial Cells.—The gradual shedding of the epithelium of the urinary tract, which occurs to some extent even under normal conditions, leads to the appearance of small numbers of epithelial cells in the urine of even quite healthy persons, and such cells form the organised constituents of the nubecula. In pathological states such cells may be present in much larger numbers and acquire considerable clinical significance. The epithelium lining the several portions of the urinary tract is composed of cells which differ somewhat widely in their forms and sizes, and it is possible for the trained eye to form a fairly definite notion of the source from which particular varieties of such cells met with in the urine are derived, but such recognition is apt to be rendered difficult by the changes produced by the liquid in which they are suspended, and especially by those due to the reaction of the urine.

It is usually an easy matter to recognise the groups of large flat polygonal cells, with sharply defined nuclei, which so frequently find their way into the urine of female patients and are of a vaginal origin, but it must not be forgotten that somewhat similar cells may be derived from the bladder, ureters, and urethra.

Again, the small round cells of the renal tubules, with their sharply defined nuclei, are liable to be confused with leucocytes, and further evidence of their origin must be afforded by the simultaneous presence of renal casts.

Other forms which admit of recognition are the conical or tailed cells of the pelvis of the kidney, but it must not be forgotten that cells of a similar character are also found in the neck of the bladder and in the prostatic portion of the urethra.

Fragments of malignant growths are occasionally met with, especially when the growth is situated in the bladder and is of the villous variety. As a rule a diagnosis can only be made when a definite mass derived from the tumour is passed, as is not infrequently the case, but Délépine considers that the repeated appearance of cells of great size, with several nuclei or a single very large nucleus, should excite strong suspicion, especially if other symptoms of malignant growth, such as vesical pain and hæmaturia, are also present.

Casts.—The forms and sizes of the objects known as urinary casts, as well as the characters of the epithelial cells which frequently adhere to them or of which they may almost entirely be made up, indicate their origin in the tubules of the kidneys. If further proof is needed it is afforded by the fact that structures apparently identical are frequently seen occupying the tubules in microscopical sections of diseased kidneys.

The casts are of several different kinds which call for individual description, and it will be well to consider first those of the so-called hyaline variety.

Hyaline casts are extremely transparent objects, the refractive power of which differs so little from that of the urine in which they lie that their outlines are often ill-defined, and they may escape detection unless carefully looked for. In searching for them it is best to employ an oblique sub-stage illumination or a very small diaphragm, and in case of doubt staining agents, such as a solution of iodine with potassium iodide, may be added. Their chemical nature and mode of origin are still in doubt, as their reactions with chemical agents do not agree with those of any other known proteid material. This is true of fibrin, of which they were once supposed to consist, as well as of other proteids, but it is possible that the material of which they are formed has undergone some change under the influence of the urine. It has been suggested by some that they have their origin in a secretion of the renal epithelium, whereas others hold that they consist of coagulated albumin which has undergone some hyaline change. The latter view gains support from the fact that their presence is in the great majority of cases associated with that of albumin in the urine.

Hyaline casts are roughly cylindrical in form, of various lengths and sometimes convoluted. Their ends may be rounded or as if broken across.

Adherent to the surfaces of the casts may be small epithelial cells, such as line the renal tubules, a few red blood corpuscles or leucocytes, or crystals of calcium oxalate or amorphous urates.

Such casts are met with in all forms of albuminuria which are associated with disorders, whether primary or secondary, of the kidneys. They have occasionally been found in small numbers in cases in which the urine is albumin-free, and are usually present in the urine of jaundiced patients. The presence of adherent renal cells or blood corpuscles adds to the importance attaching to their occurrence, indicating a grosser lesion of the kidneys. In acute nephritis such casts are often abundantly present, together with casts of other varieties.

Amyloid casts are usually broader than the hyaline, they have rounded or broken ends, and sometimes show signs of segmentation. Although homogeneous in structure they are much less transparent than hyaline casts and often have a yellowish tint. With iodine they acquire a brown colour and they are stained pink by methyl violet, but not infrequently these "amyloid" reactions are very imperfectly obtained. The presence of casts of this character affords no evidence of lardaceous disease of the kidneys; they are frequently met with in cases of chronic parenchymatous nephritis, very seldom in cases of granular kidney.

The most probable view of their origin is that they are derived from epithelial casts, next to be described, and that the cells of which they were composed have become converted into a homogeneous waxy material, under the influence of the urine, during a somewhat prolonged sojourn in the renal tubules.

Epithelial casts consist almost entirely of epithelial cells such as are met with in the renal tubules, and often present the appearance of a complete cast of the lining of the tubule. In all probability they usually contain a core of hyaline material, and this view receives support from the fact that one occasionally meets with examples of which one portion is covered with epithelial cells, whereas the remainder looks like a bare hyaline core. In the early stages of acute nephritis the individual epithelial cells are often very clearly defined, but in other instances they show signs of fusion which, when it reaches a more advanced degree, probably results in their conversion into casts of the amyloid variety. In chronic parenchymatous nephritis similar casts are met with, and as offering samples of the renal epithelium they afford valuable evidence of its condition, for the cells in the more advanced cases show signs of granular or fatty degeneration.

Blood casts, composed of red blood corpuscles, are also commonly seen in the acute stage of parenchymatous nephritis. Their presence is of some importance, as affording evidence that in cases in which they occur the blood present in the urine is derived from the kidneys.

Leucocyte casts are much less common, although a few leucocytes are not rarely seen attached to hyaline casts.

Granular casts appear to be made up of finer or coarser granules, often with an admixture of small, highly refractive fat globules. Such casts, which usually have a yellow or brownish tint, probably consist of the products of degeneration of epithelial cells and of red blood corpuscles. They vary greatly in size, and may be as narrow as those of the hyaline, or as broad as those of the amyloid varieties.

Fatty casts are of various kinds, the fat globules being still included in epithelial cells, or free and adherent to a hyaline matrix or intermixed with granular débris. Von Jaksch describes the occurrence of fat crystals as well as of the usual highly refractive globules. The presence of any considerable amount of fat in casts is of grave significance, indicating as it does an advanced stage of degeneration of the renal epithelium. Fatty casts are specially common in the later stages of severe cases of chronic parenchymatous nephritis. In case of doubt the presence of fat may be rendered certain by staining with osmic acid.

Hæmoglobin Casts.—In cases of hæmoglobinuria the granular débris contains numerous casts composed of dark brown granules, which have apparently assumed this form in the renal tubules.

Uratic Casts.—Casts composed of crystals of ammonium urate are often met with in the urine of young infants, but it must not be forgotten that the particles of which amorphous urate or ammonium urate sediments are composed are apt to assume a grouping which recalls the shape of renal casts.

Animal Parasites.—The most important of the animal parasites which are met with in urine are the ova of *Bilharzia hæmatobia*, as their presence is diagnostic of the nature of the hæmaturia by which they are accompanied. They are oval in shape and are characterised by the spine-like process which either occupies a terminal position or emerges from one side of the ovum. They are readily seen with a moderate microscopic power, their average dimensions being 0·12 by 0·04 mm. Within the shell of the ovum the ciliated embryo may often be clearly seen.

Hydatid hooklets and the remnants of hydatid cysts are occasionally met with in urine, their presence being almost always due to the rupture into the urinary tract of hydatid cysts situated in some adjacent part, but the occasional development of such cysts in the urinary passages themselves has been described. The hooklets are readily recognised by their characteristic shape, and occasionally small scolices are passed entire.

The *Filaria sanguinis hominis* has also been occasionally found in the urine.

Some parasites occur in the urine as mere accidental contaminations. Thus *Pediculus pubis* is occasionally met with, and threadworms may make their way into the urine after it leaves the bladder, or through a fistulous communication between the intestinal and urinary tracts. Certain infusoria, such as *Trichomonas vaginalis,* and acari derived from starch used as a dusting powder, have also been found.

Accidental Solid Contaminations.—Of these by far the most important is starch which is so largely used in dusting powders, especially in hospitals, and which is very frequently mistaken by beginners for a crystalline sediment. The form of the granules, which may form an abundant sediment, differs according to the source from which the starch is derived, and they may be oval or polygonal in shape. They are highly refractive, and for the most part show a dark central star by which their nature is easily recognised. When any doubt remains, advantage may be taken of the deep blue colour imparted to them by iodine.

Fibres derived from clothing, either coloured or otherwise, are frequently seen, and it is possible to distinguish fibres of cotton, linen, wool, and silk.

Hairs also call for mention. They are usually pubic in their origin, but it should not be forgotten that hairs present in the urine may be derived from dermoid cysts communicating with the urinary passages.

XVII. Urinary Calculi

Of the substances which are apt to be deposited from the urine in the form of sediments not a few are liable to form actual concretions in the kidney itself, which may increase in size in the renal pelvis or in the bladder, and so give rise to the various symptoms and to the group of serious morbid changes which are apt to result from their presence.

The great majority of such calculi are composed of uric acid, calcium oxalate or earthy phosphates, and many of them are of mixed composition. Thus a nucleus composed of uric acid or calcium oxalate may, by its presence in the pelvis of the kidney or in the bladder, set up changes which result in the urine undergoing alkaline decomposition and the deposition of earthy phosphates upon the surface of the stone.

The conditions which determine the commencement of calculus formation are not yet fully known, but calculi contain a certain amount of organic material, which may perhaps play a not unimportant part in the formation of compact concretions instead of a mere discrete sediment.

When a nucleus is once formed further deposition upon it readily occurs, as is well seen in those cases in which a foreign body lying in a bladder in which ammoniacal decomposition is going on becomes encrusted with earthy phosphates. In the same way even a calculus or uniform composition usually bears evidence of the deposition upon it of successive layers of the ground material, and a nucleus of somewhat different structure from the rest may usually be distinguished.

Metamorphotic changes may also occur, as for example when a uric acid calculus lies for a long time in a bladder containing alkaline urine.

Under such conditions some of the material of the calculus may undergo solution, and may be replaced by a deposit of earthy phosphates.

Uric acid calculi are the commonest of all. They vary in size from small spherules no larger than pin-heads, which are usually multiple and are probably formed in the renal tubules, to vesical stones as large as hens' eggs. The small particles of gravel are seen on section to have a radiating crystalline structure and the larger stones are composed of concentric layers which are apt to separate in flakes when the calculus is broken up.

Like crystalline sediments of uric acid such calculi are always coloured by included urinary pigments, and exhibit a yellow or reddish brown tint. Their surface is usually smooth, but may be slightly granular. Calculi formed in the renal pelvis are apt to assume peculiar forms corresponding to that of the irregular cavity in which they lie, but uric acid stones from the bladder are usually oval in form and somewhat flattened.

On section distinct interposed layers of calcium oxalate are sometimes seen in stones of this character, and phosphatic stones are often found to have one or more small uric acid concretions as their nucleus.

The nature of uric acid calculi may be recognised by the fact that when burnt upon platinum foil they leave no considerable ash, showing the absence of fixed alkalies or alkaline earths, and when heated with caustic alkali they give off little or no ammonia. On the other hand, they yield the murexide test, *i.e.* when a portion of the material of the stone is heated with nitric acid upon a piece of white porcelain and the acid is evaporated to dryness a reddish colour appears which changes to purple on the addition of ammonia.

In the case of mixed stones a portion of one of the broken laminæ, believed to be composed of uric acid, may be subjected to the above tests.

Uratic Stones.—A secondary deposit of urates is not uncommon upon a nucleus of uric acid, and in young infants small urate calculi, soft and easily friable when dried, and tinted like those of uric acid, are not uncommonly met with. The nature of such layers or calculi may be recognised by the fact that they yield the murexide test, but also give off ammonia freely when heated with a caustic alkali.

Calcium Oxalate Calculi.—These are the hardest of all urinary stones, and, like those of uric acid, vary in size from a fine gravel to calculi of considerable dimensions. The smaller concretions may be smooth or may exhibit spinous processes, or again may have surfaces composed of almost colourless crystals of calcium oxalate. The most characteristic are the familiar mulberry calculi, with nodular surfaces and black or dark brown in colour.

On section they are seen to be composed of narrow concentric crystalline layers with intermediate deeply-pigmented zones, the included pigment being in all probability a derivative of hæmoglobin. There is usually a definite nucleus which is more coarsely crystalline. The structure of these stones has been minutely studied and described by Ord and Shattock.

Calcium oxalate dissolves in hydrochloric acid without effervescence. When moderately heated the oxalate becomes converted into carbonate, which effervesces with acids, and by heating in the blowpipe flame this becomes further decomposed, leaving a residue of calcium oxide.

Phosphatic calculi are usually formed around a nucleus of some other material, and occasionally around a foreign body, such as the broken end of a catheter. They are chiefly formed in the bladder, and consist, as a rule, of a mixture of the phosphates of calcium and magnesium, with ammonio-magnesium or triple phosphate. The last-named salt is formed as the result of ammoniacal decomposition of the urine.

Rarely small calculi composed of calcium phosphate alone are met with, as in some cases of disease, such as osteomalacia, in which the bones are largely deprived of their inorganic constituent. Such stones are usually small, large well-formed crystals may project from their surfaces, and on section they show a distinct crystalline structure.

Calculi composed of a mixture of calcium and ammonio-magnesium phosphates are known as fusible calculi, because they have the property of melting when heated over the blowpipe flame.

Phosphatic stones are colourless or only feebly tinted, are as a rule soft, and may attain to a large size. They dissolve in hydrochloric acid, without effervescence, both before and after incineration, and the solution yields the phosphoric acid reaction with ammonium molybdate.

The presence of triple phosphate may be detected by the free evolution of ammonia on heating with caustic potash or soda.

Calcium Carbonate.—Calculi composed wholly or in large part of calcium carbonate are not common in man, although not infrequently met with in vegetable feeding animals. They require an alkaline medium rich in carbonic acid, such as decomposing urine, for their formation. They are usually amorphous, soft, crumbly, and almost colourless. They are readily recognised by the fact that they dissolve readily in acids with effervescence, whereas those composed of calcium oxalate only dissolve with effervescence after incineration.

Cystin calculi are decidedly rare, because cystinuria is a very rare condition, but on the other hand a large proportion of cystinuric individuals form calculi at some period. Not infrequently a succession of small calculi is passed by such patients, giving rise to a series of more or less serious troubles, but in other instances such stones attain to a large size.

The nature of such calculi is usually easy of recognition. They are pale in colour, usually have a granular surface, and on section appear crystalline and very slightly yellow-tinted. When kept for long periods they tend to acquire a green tint.

Cystin stones leave practically no residue on combustion, and burn with a bluish flame. A fragment of the calculus is readily dissolved by ammonia, and on standing the ammoniacal solution deposits the characteristic hexagonal colourless plates similar to those of which cystin sediments are composed. To obtain good crystals it is advisable to use *dilute* ammonia as a solvent.

Xanthin calculi are very much rarer still, and only six or seven examples have been recorded. The first of these was described by Marcet in the early years of the last century.

They have for the most part occurred in children. They are usually smooth, of a brownish cinnamon tint, are moderately hard, and a polish may be imparted to the surface by rubbing. Such calculi leave practically no residue on combustion. When heated with nitric acid upon a porcelain dish the material leaves a *yellow* residue, which when caustic soda is added assumes a red colour and on warming a purple tint. This is the characteristic xanthin reaction which must be distinguished from the murexide reaction of uric acid.

Cholesterin Calculi.—It would seem probable that calculi rich in cholesterin removed or passed from the urinary bladder have usually been gall-stones which have found their way thither through a fistulous passage.

Some have undoubtedly been of this nature, being facetted and rich in bile-pigment, and associated with the passage of bile in the urine of patients who were not jaundiced.

However, no such origin can be ascribed to a remarkable stone examined by Horbaczewski, which contained 95·87 per cent of cholesterin. It had been removed by supra-pubic lithotomy from the bladder of a little girl aged six, and had been regarded as a cystin stone. The calculus weighed no less than 25·4 grammes.

Indigo Calculi.—Small renal calculi consisting of indigo have been described by two or three observers, the earliest example by W. M. Ord.

Urostealith.—Under this name are classed certain very rare concretions found in the bladder, which are soft and elastic in the moist state, but friable when dried. They burn with a luminous flame, and in burning emit an aromatic odour. In some specimens analysed by Horbaczewski a large proportion of the organic material was soluble in ether, and the residue from the ethereal extract consisted of fats and fatty acids, with traces of cholesterin.

The origin and mode of formation of such calculi are quite unknown.

XVIII. Drugs, Poisons, Accidental Constituents of Urine

In this final section it will be necessary to speak of certain substances met with in the urine which in themselves are of no clinical importance, but which it is necessary to recognise if only for this reason.

Various drugs and also poisonous substances appear in the urine either unaltered, or after undergoing changes in the body, and influence its properties.

Some of these may be recognised by the odour which they impart, such as copaiba and turpentine, which latter when ingested causes the urine to smell of violets.

Others again influence the colour, as for instance santonin, which imparts a peculiar bright yellow tint which changes to a beautiful pink with excess of an alkali. Chrysophanic acid, too, which is contained in rhubarb and senna and appears in the urine when they are taken, yields a pink tint with alkalies. The urine of patients taking salicylates sometimes has a brown colour, and may have a slight reducing action upon Fehling's solution. The presence of salicylates is easily detected by the purple colour which appears in the path of a falling drop of ferric chloride solution. This test is best performed with diluted urine, as otherwise the purple colour is apt to be masked by precipitated phosphates.

The peculiar greenish brown colour of carboluria is ascribed by Baumann and others to the presence of hydroquinone. Phenol cannot be detected in such urines by its colour test with ferric chloride, as it exists in them in the form of an aromatic sulphate. The presence of an excessive amount of ethereal sulphate serves as a useful test in such cases, for the urine gives little or even no precipitate with a barium salt, whereas, after boiling with hydrochloric acid a copious precipitation of barium, sulphate will be obtained.

Carboluria occurs after the administration of phenol by the mouth, or after the application of carbolic compresses, especially to children. It is also often seen after the administration of salol.

In cases of picric acid poisoning the urine has a red colour from a partial conversion of the picric into picramic acid. Picric acid may be extracted from such urine by shaking with ether, to which it imparts a yellow tint.

Urine containing copaiba not only has a highly characteristic odour, but it yields with cold nitric acid an opaque white ring which may be mistaken for albumin, and with hydrochloric acid a purplish colour which shows a characteristic spectrum of three absorption bands.

Rosaniline gives a pink colour to the urine of patients who are taking it, and methylin-blue imparts a brilliant green tint, or a blue colour if large doses have been taken.

The pink pigment with a bright green fluorescence which results from the eating of certain kinds of sweetmeats may also be again referred to.

Bromides and iodides may be recognised by the addition of chlorine water, which sets free their halogen components. On shaking with chloroform the latter is coloured brown by bromine and purple by iodine. It should be remembered that urine containing iodide yields a blue colour with guaiacum and ozonic ether, but rather more slowly than blood-stained urine.

Hæmatoporphyrinuria may result from the administration of sulphonal and its allies.

Some poisons produce conspicuous changes in the urine which are due to injury done in their passage. Thus cantharides or turpentine may produce hæmaturia by irritating the kidneys, and potassium chlorate in poisonous doses may set free hæmoglobin in the blood, and so cause a copious excretion of methæmoglobin.

Many other drugs and tonic substances may be recognised in urine, but the processes for their detection do not fall within the scope of this article.

LITERATURE.—The following list includes a number of works which treat of the urine in its pathological aspects. Several of these, and especially that of Neubauer and Vogel, give references to large numbers of papers dealing with special points. This list is supplemented by a certain number of references to papers referred to in the article, most of which have been published very recently, and are therefore not included in the bibliographies referred to, whilst some older ones are included because of their special importance.

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The urine as contained in the healthy bladder is normally free from bacteria.

The exact significance to be attached to the presence of bacteria in the urine depends in no small degree on the recognition of the channel through which the infection has taken place.

Modes of Infection.—A. *Infection from Without.*—Urine passed in the everyday manner, received in a sterile vessel and preserved from contact with the air, does not always remain sterile, for the normal urethra, male or female, nearly always contains bacteria.

Lustgarten and Mannaberg (1), who were the first to investigate the flora of the healthy urethra, found in stained films, or in cultures, the smegma bacillus, the pseudo-gonococcus, and the staphylococcus pyogenes aureus, besides other organisms of less importance.

Rovsing (2) was able to recover nearly all the organisms which he had already described as occurring in cystitis.

Melchior (3) found the streptococcus pyogenes and the bacillus coli communis, as well as other organisms.

Petit and Wassermann (4), on the other hand, found neither pathogenic organisms nor the ordinary organisms of cystitis.

Schenk and Austerlitz (5) investigated the bacteriology of the urethra in healthy women. After cleansing not only the meatus, *but also the anterior part of the urethra,* they found the urethra sterile in thirty out of sixty cases. In only two cases out of the others were pathogenic organisms found. In the remaining twenty-eight cases they identified the organisms present with those commonly found in the vestibule, and concluded that they had migrated thence into the urethra. It is obvious that an infection in this way is more likely to occur in women than in men.

Melchior (3) found the bacilli coli communis in the vagina or on the vulva of women in half the cases which he examined, and not infrequently in the preputial secretion of men.

It is seen, therefore, that in a large proportion of cases the healthy urethra and external genital organs abound in organisms which may be carried to the bladder, and give rise to an infection of the urine or of the bladder wall if the conditions are favourable, even when the greatest care is taken in the sterilisation of instruments. The passage of instruments is by far the commonest cause of infection, although, fortunately, the other conditions do not favour the growth of bacteria in the urine, except in a very small proportion of cases.

Where there exists any microbic infection of the urethra the risk of infection attending catheterisation is, of course, greatly increased.

In women it is probably owing to the shortness of the urethra, combined with the liability of the parts to injury during parturition, and the more frequent occurrence of disease in the neighbouring parts, that bacteria may make their way into the bladder by the urethra without the aid of a catheter.

In men they are not likely to do so except by the direct extension backwards of an infective process in the urethra.

B. *By direct extension of disease from neighbouring organs.*

Abscesses arising in various parts may burst into the bladder, or fistulous communications may be established with the bowel. An inflammation of any of the surrounding structures may implicate the bladder wall directly, and sometimes the bladder may become infected indirectly, by the blood or lymph stream, from disease of a neighbouring organ.

C. *From the kidney and ureter.*

In infection of the kidney, with gross lesions, it is universally admitted that urinary infection frequently occurs. It is still disputed, however, whether a healthy kidney will allow the passage of bacteria from the blood stream into the urine.

It is known that in certain diseases, *e.g.* typhoid, pneumonia, and erysipelas, the specific micro-organisms sometimes make their appearance in the urine. In some of these cases the urine remains free from albumin, and at the same time there may be no symptoms of any affection of the kidney. Moreover, the kidney may be found healthy and free from infection on post-mortem examination. It has been argued, however, that morbid changes actually occur in these cases, but are only microscopical in degree and insufficient to give rise to any appreciable symptoms. It is manifestly almost impossible to disprove this theory as regards man, for it would entail, among other things, a complete histological examination of the kidneys by means of serial sections.

Much of the experimental evidence is vitiated by the fact that the number of organisms injected into the circulation was larger than is within the fair limits of experiment.

Wyssokowitsch (6) showed that microbes injected into the circulation of animals rapidly diminish in number, and that saprophytes soon disappear altogether, whereas organisms which are pathogenic for the species experimented on show a subsequent increase. He denied that physiological excretion ever took place. He failed to find injected bacteria in the urine before such time as he considered necessary for gross lesions of the kidney to be produced, and was always able to demonstrate naked-eye extravasation or small foci of cellular infiltration post-mortem when he found organisms in the urine. On the other hand, Biedl and Kraus (7) were able to recover from the urine, in some cases at the end of twelve minutes, organisms which they had injected into the blood stream, and they assumed that no change could have taken place in the kidney in so short a time. Von Klecki (8), using much smaller quantities, confirmed their results, in one experiment finding the organisms in the urine as early as three minutes after injection. He also found that they ceased to appear in the urine before they had disappeared from the circulation. On microscopical examination, after killing the animal, the organisms could be seen lying in the glomeruli without any associated histological change.

Although objections can be and have been taken to the conclusion drawn from these experiments, namely, that organisms can pass through the "intact" kidney, the discussion is rather of academic interest, for it is clear that if some structural alteration is necessary before this can occur, it must be infinitesimal in degree and certainly less than can be appreciated clinically. In almost any severe infection where organisms may at one time or other be found circulating in the blood, the conditions in the kidney are such as would favour an escape of bacteria from it into the urine.

Kraus (9), working at the urinary infections in infective diseases, recovered organisms from the urine in thirty-six out of seventy cases, but he only found those of the specific process in cases of typhoid fever and puerperal infections. The results of Kraus are of great interest because they tend to show that, with a lowered resistance, arising from many and varied infections, any organisms may penetrate into the blood-stream from the intestine, the pharynx, or other mucous surface which is not itself the seat of the morbid process. It follows from this that organisms found in the circulating blood are not necessarily those of the primary disease.

A large number of recent observations point to the same conclusion.

Posner and Lewin (10) have shown that by simultaneous mechanical occlusion of the anus and urethra a general infection can be caused, and that organisms will then be found in the urine. That the urinary infection is not due to direct extension from the rectum to the bladder but takes place indirectly through the blood stream, is proved by the fact that if one renal artery is also ligatured, infection of the corresponding kidney does not occur.

Of late years a good deal of attention has been directed to cases in man, of cystitis or bacteriuria, where this mode of origin has seemed probable. Hutinel (11), Hogge (12), and others have pointed out the frequent association of cystitis and intestinal affections, the urinary infections in some cases probably taking place indirectly by way of the circulation.

D. *Infection of the bladder by the blood stream.*

Although there is no theoretical objection to the *bladder* becoming infected and secondarily infecting the urine in this way, there is no evidence that this often happens. The best example is to be found in tubercular disease of the bladder, which sometimes occurs in the absence of any affection of any other part of the genito-urinary tract.

The precautions which must be taken in collecting samples of urine for bacteriological examination vary considerably with the nature of the investigation required.

For all ordinary purposes in the male, at any rate, it is sufficient after cleansing the meatus to allow the patient to pass some of his urine into a sterilised vessel; the first portion, which is more likely to contain organisms from the urethra, being rejected. In the female it is always necessary to withdraw a specimen with a sterilised catheter, care being taken to avoid contamination of the instrument by the external genitals. Into the procedure necessary in those cases where it is of vital importance to exclude every possibility of contamination from the urethra, or where it is desirable to remove urine from one or other ureter, there is no need to enter here. In any case all cultural examinations should be made immediately. A very short delay in so doing is sufficient to vitiate any result.

Cystitis.—The exact bacteriological examination of the urine in cases of cystitis is of quite recent growth.

The researches of Bumm (13), Clado (14), Albarran and Hallé (15), Rovsing (2), Krogius (16), and more especially of Melchior (3), following rapidly on one another, served to prove that cystitis might be caused by a number of different organisms. A comparison of their work, however, shows that certain of the organisms in question, notably bacillus coli, had been described under several names, so that the total number of the different varieties commonly found is much smaller than appeared at one time probable. It is true also that, even allowing for this, the results obtained varied considerably with the different observers. The reason for this latter circumstance is at once seen if the widely differing clinical fields from which their material was drawn are considered. Their investigations have been repeated by a very large number of other workers without much being added to our stock of knowledge on this point. The sum of all this work shows that, including all cases of cystitis in both sexes, the bacillus coli is the commonest organism found, and after that in turn the staphylococcus aureus and albus, proteus vulgaris, streptococcus pyogenes, and the gonococcus. Less frequently the bacillus typhosus, the pneumococcus, and Friedländer's bacillus may be present. Finally, a large number of other organisms, not otherwise pathogenic for man, have been described as occurring occasionally.

Any of these bacteria may be present in pure culture, but two or three or even more varieties may be found in the same urine. It is important to bear this in mind, lest, for example, the presence of the bacillus coli or one of the pyogenic cocci in a specimen of urine should lead to the gonococcus, or the tubercle bacillus, which may be associated with them, being overlooked.

The attempts which have been made to associate special organisms with different forms of cystitis have not stood the test of time. It is possible, of course, to classify the causes of cystitis according to the organism present, but the classification would give no clue to the character or intensity of the inflammation in any given case. The reaction of the urine as freshly passed does vary, however, with the organism. In the majority of cases it is acid in correspondence with the preponderance of cases caused by the bacillus coli. In cystitis, due to the gonococcus or the tubercle bacillus, the urine is also acid. When the pyogenic cocci are present the urine presents usually a diminished acidity or may be faintly alkaline. In the presence of proteus vulgaris the reaction is strongly alkaline (ammoniacal), and the same is true in the case of some of the less frequently found organisms already mentioned. Very little is known of strictly anaërobic organisms as a cause of cystitis, but Albarran and Collet (17) have described them as occurring in periurethral abscesses and extravasations of urine. Their presence is usually marked by a foul smell.

All attempts to produce cystitis by the mere injection of organisms into the healthy bladder have failed except in those cases in which the proteus vulgaris was the one employed. The bacteria are gradually expelled, and after three or four days, as a rule, no trace of them can be found in the urine. It should be noted that not even bacteriuria can be produced in this way. If, however, retention of urine be produced, or some injury be done to the bladder, or a small stone be introduced, then, the injection into the bladder of any of the usually found organisms will set up a cystitis, though retention or a like injury by themselves do not. This coincides with what is found in man under natural conditions. As we have seen, organisms must often reach the bladder from the kidney or through the urethra, but if the bladder be healthy and capable of emptying itself no multiplication takes place.

Between bacteriuria, in which bacteria alone are present as an abnormal constituent of the urine, and cystitis the writer does not think it is possible to draw any hard and fast line either clinically or pathologically. On centrifugalising the urine, leucocytes and epithelial cells are always to be found in every bacteriuria, and a continuous series can be traced from such cases through all the stages up to the most severe purulent cases of cystitis. The healthy bladder with normal urine is a barrier against bacteriuria, even as it is against cystitis. If this were not so bacteriuria would follow the passage of a catheter in a very large proportion of cases. The difference between cystitis and bacteriuria is merely one of degree, and depends partly on the virulence of the organism, partly on the resistance of the patient, modified as it may be by so many causes local or general.

In certain rare cases cystitis may be due to chemical irritants such as cantharides, and under such circumstances the urine may remain free from micro-organisms.

In pyelitis, pyelo-nephritis, and ascending nephritis, the organisms found are those commonly present in cystitis.

NEPHRITIS.—In infective processes associated nephritis may be due to the circulating toxines, and organisms may be absent from the kidney and the urine. In other cases the organisms of the primary disease or of some secondary infection may be present in the kidney and pass into the urine. In so-called primary nephritis, Mannaberg (18) found streptococci, Letzerich (19) bacilli, but their etiological connection with the disease is doubtful.

INFECTIVE DISEASES.—Examination of the urine in infective diseases gives varying results. It is gradually becoming more and more evident that, even in diseases, *e.g.* typhoid, in which the morbid processes are more or less restricted to certain situations, the organisms must at some time or other circulate in the blood stream. In certain pyogenic infections, *e.g.* acute osteo-myelitis, the condition is often complicated by a true septicæmia, and the organisms are constantly in the blood in greater or less numbers. On the other hand, in tetanus the organisms have never been found except locally. The oftener organisms find their way into the blood stream the greater will be the frequency of their appearance in the urine. Unfortunately their presence there is no indication of a specific nephritis, for, as we have seen, the organisms may be absent from the kidney after death when they have been discovered in the urine during life; nor does it necessarily imply a severe blood infection, in other words, a true septicæmia, for a few stray organisms may escape by the kidney.

It is, however, safe to say that in any given disease, for obvious reasons, an infection of the urine is more likely to occur in severe than in mild cases.

In addition it must be remembered that any lowered resistance of the body favours the penetration into the blood stream of organisms commonly living as saprophytes on the mucous surfaces of the body. Organisms found circulating in the blood are therefore not necessarily those of the specific disease. This is true also as regards the urine. If, therefore, the organisms found in the urine belong to the class which commonly lives on the mucous or even skin surfaces of the body saprophytically, the conclusions drawn from their presence must be very guarded. This objection does not weigh against those organisms which are only found in the body in diseased conditions.

The specific organisms of the disease have been found frequently in the urine in pneumonia and other pneumococcal infections, in malignant endocarditis, erysipelas, puerperal septicæmia, and many other pyogenic infections in plague, glanders, and typhoid fever. The significance to be attached to their discovery may be gathered from the immediately preceding sentences.

The identification of these organisms can only be arrived at by cultural experiment. Their presence in the urine indicates the need for its disinfection. This is more especially so in the case of typhoid fever.

Typhoid Fever.—Of all general diseases of microbic origin typhoid fever is the one in which the specific organisms are most often present in the urine.

Gaffky (20), who may be called one of the discoverers of the typhoid bacillus, found it in the kidney in three cases out of seven. It has been since found by many observers in many cases. It is not, however, so frequently recovered culturally from that organ as from the spleen and abdominal lymphatic glands, partly, no doubt, owing to its being present in smaller numbers, but partly also owing to the kidney being less succulent, and so presenting less favourable material for cultivations as commonly carried out.

Seitz (21) was the first to describe its occurrence in the urine, and his results were soon confirmed by Konjajeff (22), Neumann (23), Karlinski (24), and others. These earlier cases are, of course, open to the objection that affects all the early attempts at the identification of the typhoid bacillus, viz., the absence of sufficient data for distinguishing it from the bacillus coli.

Horton Smith (25), Petruschky (26), and Richardson (27) were the first to apply the serum agglutination test to the organisms they obtained, and so to prove as absolutely as we are able their specific nature.

Typhoid bacilli have been found in the urine by different observers in a varying proportion of the cases examined. Neumann (23) found them in 11 cases out of 48 cases examined—8 times in countless numbers. In 2 other cases he found the streptococcus pyogenes in pure culture. Horton Smith (25) found them in 17 cases out of 45; Richardson (27), in 23 out of 103. Other observers have found them in varying proportion, from under 10 up to 100 per cent of the cases examined.

It is now generally held that in any large series taken consecutively without selection, they are to be found in about 25 per cent of the cases. In a large proportion of such positive cases, as pointed out first by Neumann (23), they are present in very large numbers, making the urine as freshly passed quite turbid, and on shaking the urine, if it be in a glass vessel, it presents a peculiar shimmering appearance which is very suggestive. As a good deal of stress has been laid on this point by many writers, it may be pointed out that the same appearances can be seen in bacteriuria caused by other organisms, so that its significance is very limited. In other cases the bacteria are relatively scanty in number—a fact which suggests that in some of the "negative" cases they may have escaped detection owing to this circumstance. Wright and Semple (28), who incubated large quantities of the urine directly, found the organism in six out of seven cases, and as early as the tenth day. Their identification of the bacillus was not as complete as with our present knowledge it might have been, but their large proportion of positive results may have been due, not to error, but to the large quantity of material taken. In addition to the bacteria the urine commonly contains albumin often in small amount, but it may entirely be absent; a few pus cells and epithelial cells can, however, be always found.

In the condition already described there is an infection of the urine, the bacilli multiply in it, but the bladder wall is not obviously affected, and the signs and symptoms of cystitis are practically absent. On the other hand, in a small proportion of cases pus and bladder epithelium may be present in large amount and the symptoms of cystitis appear. Between these two extremes there are cases of every degree of severity.

In addition to the cases where the infection seems limited to the bladder, or its contained urine, there are others in which the chief urinary symptoms point to the kidney. Albumin, casts, and perhaps blood appear; hæmaturia, indeed, may in rare cases be the first sign of serious illness. It must not be supposed that all cases of nephritis occurring in typhoid fever are due to the typhoid bacilli, for in some of these cases they may be absent from the urine and even from the kidney. There is, indeed, no good evidence to show that the nephritis is ever due to the actual presence of the typhoid bacillus itself apart from its toxin. The changes in the kidney are not restricted to the area of the small lymphoid nodules in which the typhoid bacilli usually lie when present in the organ.

Date of Appearance.—With some doubtful exceptions there are no records of the appearance of bacilli in the urine before the end of the second week; on the other hand, they may be noticed for the first time three or four weeks, or even more, after the temperature has become normal.

The condition, whether of cystitis or merely bacteriuria, has a tendency to disappear spontaneously, as a rule, in two or three weeks, but this period may be greatly exceeded. Gwynn (29) has recorded a case where the patient suffered from cystitis for four years after an attack of typhoid fever, the typhoid bacillus being recovered at the end of that time, and Young (30) a case lasting seven years. Houston (31) found this organism in a case of cystitis which had lasted three years, and which dated from the time the patient had nursed a child with "diarrhœa." There was no evidence that the patient herself had suffered from typhoid fever.

Neumann (23) has tried to prove that the urinary infection coincides with the eruption of the roseola, and now that it is known that the rose spots contain the specific organism, there can be no difficulty in accepting the view that an overflow of typhoid bacilli into the blood stream may infect the kidney and the skin simultaneously. In this case it might be expected that cases would be recorded as occurring earlier than at present is admitted, in a correspondence with the date of appearance of the rash, but it is probable that in the earlier stages of the disease, at the time of the first appearance of the eruption, the bladder is in a condition to resist infection. On the other hand, Osler (32) records twelve cases of typhoid fever in which rose spots made their appearance during an apyrexial period. These may be taken as analogous to the late appearance of the bacteriuria.

In the prevention of the spread of typhoid fever the disinfection of the urine of patients suffering from this disease now plays a large part. The late appearance of the organisms ought to be borne in mind, and an eye kept on the condition of the urine for some weeks after the temperature has become normal.

Cystitis and bacteriuria occurring in the course of typhoid fever are not always caused by the typhoid bacillus. The bacillus coli, the streptococcus pyogenes, and the staphylococcus pyogenes aureus are the more likely foreign organisms to be found, and they may be present in pure culture or associated with the specific organism.

The organism can only be positively identified by careful and thorough bacteriological examination.

Tubercle Bacillus.—Tubercle bacilli are present in the urine only when there exists some tubercular affection of the genito-urinary tract.

Phillippowicz, quoted by Sherrington (33), it is true, claimed to have demonstrated them in the urine of a case of general tuberculosis in which the kidneys after death showed no tubercular lesions, but this is a solitary exception. In the early stages before ulceration has taken place, of course they are absent from the urine. Before a negative report can be justified the urine should be repeatedly examined, for when tubercle bacilli are present it may be only in very scanty numbers. They are often found lying together in small clumps of three or four to twenty or more, the intervening parts of the film showing none at all. A large quantity of the urine should be allowed to sediment, or better still, should be centrifugalised. By this latter means tubercle bacilli can sometimes be detected in cases where there is only a very small amount of ulceration, and consequently also of discharge.

The smegma bacillus, which is a common saprophyte in the vulvar and preputial secretion, and which is occasionally present in the urethra, adds considerably to the difficulty of making a diagnosis by microscopical evidence alone, since this organism in some cases will show a resistance to the action of acid *and* alcohol equal to that of the tubercle bacillus. A carefully obtained catheter specimen will often avoid this difficulty, but in cases where any doubt still remains, and indeed in every case, inoculation into a susceptible animal will decide the matter with absolute certainty.

Gonococcus.—The urine in the great majority of cases becomes first contaminated with gonococci in its passage down the urethra. True gonorrhœal cystitis does, however, occur. Wertheim (34) was able to demonstrate culturally and microscopically the presence of gonococci in a portion of the mucous membrane removed from the bladder of a young girl. When the urine contains an appreciable amount of pus, films may be made from it, if necessary, after centrifugalising. In the absence of much pus the best material to take for examination lies in the gonorrhœal "threads," which consist of shreds of mucus with adherent leucocytes. If the specimens are stained by Gram's method and counterstained by some contrasting dye, the gonococci will be found stained by the counterstain (they lose the stain in Gram's method), and any of the ordinary pyogenic cocci, if present, will be stained by the gentian violet. The typical shape and arrangement of their intracellular situation taken with this staining reaction will in a majority of the cases suffice to establish the diagnosis. When the gonococci are only present in very scanty numbers repeated examination may be necessary.

Sometimes admixture with foreign organisms renders the diagnosis by microscopical examination difficult or even impossible. In such cases of difficulty, and also where the cocci are few in number, cultural experiments, which require special media, may enable a diagnosis to be arrived at.

Actinomyces.—A large number of cases are now on record (Tuffier) (35) of actinomycosis affecting the urinary tract. The presence of the characteristic granules in the urine with a microscopical examination of fresh and stained specimens is sufficient to establish a diagnosis.

Pneumaturia.—When gas is voided with the urine there exists in most cases a fistulous communication between the bladder and the intestine.

In certain rare cases gas is actually formed in the bladder without any such lesion being present, and is then due to action of micro-organisms.

In 1883 Guiard (36) published four cases of spontaneous development of gas in the bladder. The gas was odourless, but no chemical analysis was made of it nor any proper bacteriological examination. The presence of large numbers of "vibriones" was noted in two cases. All the patients were diabetics and suffered from cystitis, and the author suggested that fermentation by some micro-organism was the cause of the gas formation. In the same year Dumenil (37) published a case of a similar nature.

In 1889 Fr. Muller (38) described a case also in a diabetic.

A bacillus was present in large numbers, but no pure culture was obtained. An elaborate analysis of the gas found in the bladder gave CO_2 19·8 per cent, N 35 per cent (probably by interchange with the gases of the blood), H 44 per cent, 0·23 per cent, CH_4 ·086 per cent.

Senator (39) demonstrated the presence of T. cerevisiae in one case, the gas being CO_2 only, and Frisch (40) the parasite of thrush (oidium albicans), and Péré (41) an organism of the coli group. The urine of all these cases contained sugar. Montt Saavedro (42) recovered Friedländer's bacillus from two cases of cystitis, with free gas in the urine. In one of these cases the urine contained no sugar. Heyse (43) and Schnitzler (44) have also published cases of pneumaturia, the former's due to the B. lactis aërogenes, the latter to B. coli, in which the urine was free from sugar. It is well to remember, as pointed out by Senator, at least as to cases where the fermentation is due to yeast, that though the urine may be free from sugar when voided, it may have contained it as secreted.

Gas forming, strictly anaërobic, organisms have been found post-mortem by Williams (45), Lindenthal (46), Dunham (47), and others, as the cause of emphysema of some part of the genito-urinary tract, free gas being also present in the urinary passages, and it is not improbable that anaërobes may be present more often than is suspected. Their presence would enable us to understand more readily those cases of gas formation in sugar-free urines which have been recorded.

Hydrothionuria.—The presence of sulphuretted hydrogen in the urine may result from the action of micro-organisms in the bladder, as shown by the cases of Rosenheim (48), Karplus (49), and Savor (50). The organism found has always been some member of the coli group. Apart from the existence of vesico-intestinal fistulæ it may be doubted whether cases of hydrothionuria can occur in any other way.

The earlier explanations of diffusion from the intestine into the bladder or excretion from the blood by the kidney of gas absorbed from the bowel may now be reasonably doubted.

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Urticaria.

Syn:—*Nettlerash, cnidosis* (*κνίδη, a nettle*).

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Definition.—Urticaria is an eruption characterised by the formation of wheals. Wheals are raised, flatly convex, circumscribed lesions, white or pinkish in colour, firm and elastic in consistence, which form rapidly, are more or less ephemeral, are associated with itching, tingling, or stinging sensations, and are similar to the lesions produced by the sting of the common nettle (*Urtica urens*), from which the eruption derives its name.

Symptoms.—The eruption may come out suddenly without warning, or it may be preceded for a day or two by various prodromal symptoms, such as fever, malaise, lassitude, nausea, vomiting, diarrhœa, and epigastric pain, or by burning and tingling of the skin locally. Wheals vary greatly in size and shape. They are usually about the size of a split-pea or a small bean and discrete, but they may coalesce to form irregular, pad-like patches sometimes as large as the palm of the hand. As a rule they are circular in outline, but they may be irregular, and occasionally take the form of streaks, crescents, or gyrate figures.

They are solid and more or less elastic to the touch, and are generally elevated about 2 mm. above the level of the skin, though at times they may be scarcely raised, and may be difficult to feel. When they first appear they are pinkish in tinge, but in most cases this colour is quickly replaced by a whitish tint which has been compared to that of porcelain. Surrounding the wheal there is a hyperæmic halo which fades gradually into the neighbouring skin. Wheals vary in number in different cases from a few isolated lesions to hundreds of them.

They do not show any tendency to be arranged systematically, or to be grouped in any special manner. They may occur in any situation in the skin, but are most liable to form in the parts covered by clothing. They may be present also in the mucous membranes, and are most common in those of the mouth, pharynx, gastro-intestinal and respiratory tracts. In the latter situation they cause sensations of suffocation and dyspnœa of the asthmatic type, and occasionally asphyxia, while in the gastro-intestinal tract they are associated with nausea, vomiting, and diarrhœa. The subjective symptoms of urticaria are not infrequently worse immediately before the wheals form, and they tend to diminish when the lesions are fully evolved. Occasionally wheals may go on to vesicular or bullous formation, and they may even become hæmorrhagic. The life of a wheal is, as a rule, brief; it generally lasts only a few minutes, but at times it may persist for several hours, and sometimes for days.

On disappearing wheals seldom leave any trace behind them, such as staining or desquamation, but on the other hand they may be replaced by a hemp-seed sized inflammatory papule, or in rare instances be followed by pigmentation. The latter sequela must on no account be confused with the disease known as urticaria pigmentosum, which belongs to a different category from true urticaria.

On account of the distressing subjective symptoms associated with the efflorescence of wheals, the patient is induced to rub the skin, and by so doing to cause more wheals to form, or he may scratch and excoriate it, and by inoculating pyogenic organisms produce pustular lesions of the type of ecthyma.

VARIETIES.—Several varieties of urticarial eruptions are distinguished, and a brief reference to these will serve to indicate the leading clinical types of the disease. There are four chief varieties of urticaria, namely: *Urticaria acuta*, *U. chronica*, *U. factitia*, and *U. papulosa.*

1. *Urticaria Acuta.*—The eruption in acute urticaria is, as a rule, associated with a rise in temperature of several degrees. Prodromal symptoms are generally present, and the condition is almost invariably the result of the circulation in the blood of food-toxins or drugs. The eruption is profuse, the wheals remaining discrete on the face, but tending to run together to form patches on the trunk and limbs. It readily disappears when the offending toxins have been eliminated and leaves no trace of its occurrence.

2. *Urticaria Chronica.*—Chronic urticaria is so named, not because the individual wheals persist much longer than those in the acute variety, but because the dermatitis is kept up for a prolonged period by successive crops of wheals, which appear at regular or irregular intervals, and sometimes exhibit a periodicity which suggests malaria. The wheals are discrete and comparatively few in number. It is often difficult to trace the cause of this condition, and it is far more intractable to treatment than the acute type.

3. *Urticaria Factitia.*—Factitious urticaria is the name given to wheals which are readily excited by local irritation. It occurs in a peculiar condition of the skin in which there is an excessive state of irritability of the nerve-mechanism which regulates the cutaneous blood-vessels. In such cases the slightest irritation results in the formation of wheals. The stroke of the finger-nail down the back produces a linear wheal, and in a marked case raised white letters with erythematous borders may be written across the back in wheals by any pointed instrument ("dermographia"). The artificial wheals may only persist for a few minutes, or they may last for several hours. In patients suffering from this condition of the skin the wheal-formation may be demonstrated even when the patient is asleep or under a general anæsthetic.

4. *Urticaria Papulosa* (*Lichen Urticatus of Bateman*).—The wheals in this type of urticaria are usually small. They are rarely white in colour, but present a pinkish tinge, and they are situated, as a rule, in the centre of an erythematous blotch. It is a disease of infancy and early childhood. In a severe case the child may be covered with the blotches in the evening. In the morning the majority of the wheals and blotches have disappeared, and have been replaced by small papules about the size of hemp-seed. These papules are intensely itchy and are generally excoriated from scratching, and capped by a tiny crust. Scratch-marks, excoriations, and pustular lesions may all be present to mask the real nature of the eruption. Occasionally vesicles or bullæ develop, these being chiefly found on the hands and feet. This singularly intractable type of urticaria is most common in infants, and is occasionally designated as "infantile urticaria." It forms one of the commonest diseases of infancy and early childhood. It is generally the result of the assimilation of some toxin from the alimentary canal. In most cases it is not associated with any general disturbance in the child's health, but there may be more or less chronic intestinal catarrh. It is rare to find it in children over ten years of age. Certain observers maintain that it may develop into the prurigo of

Hebra, but this assertion has not been satisfactorily proved, and the chief argument against it is the fact that prurigo is an exceptionally rare disease in this country, while lichen urticarius is one of the commonest of all the skin-diseases met with in any of the children's hospitals. But besides these four main types of urticaria several sub-varieties have been specially named on account of differences in the size, shape, and character of the wheals, and other purely secondary considerations. These sub-varieties do not require more than a passing reference. When the wheals form variously shaped figures the names of *Urticaria figurata*, *U. annularis*, and *U. gyrata* have been applied to them. When they are unusually large, forming deep-seated, brawny yellow or reddish tubercles, the condition has been termed *U. tuberosa* and *U. gigans*. When they occur in the lax tissue about the eyelids or genitals, and form œdematous swellings, they constitute *U. œdematosa*, a variety of which is the "acute circumscribed œdema" of Quincke. When the presence of wheals is associated with a definite rise in temperature the condition is known as *U. febrilis*. If the wheal is short-lived it has been christened *U. evanida*, in contra-distinction to wheals which persist for hours or days, *U. perstans*. When they recur in crops it is known as *U. recurrens* or *U. intermittens;* and when vesicles, bullæ, or hæmorrhages form in the course of the eruption, it is known respectively as *U. vesiculosa*, *bullosa*, and *hæmorrhagica*.

ETIOLOGY.—Urticaria in all its forms should be regarded rather as a symptom than as a disease *per se*. The wheal is the result of a peculiar reaction on the part of the vaso-motor nerves of the skin to some irritant or toxin. This may act from without like the sting of a nettle, or from within by circulating in the blood and so reaching the skin, or reflexly through the higher nerve-centres, as the urticaria which occurs in certain individuals from intense emotional excitement. But in addition to the actual wheals which are formed, the skin in the neighbourhood of them is also rendered vulnerable, and slight rubbing brings out new lesions, showing that the irritant is either widely diffused, or that a reflex instability of the vaso-motor mechanism in the neighbourhood of the wheal is established.

Idiosyncrasy also plays an important part in the etiology of urticaria. In no disease is the time-honoured axiom of "one man's food is another man's poison" more applicable, for certain articles of food which are usually harmless will, in the smallest quantities, produce a profuse urticaria in susceptible individuals. Heredity and the neurotic temperament are also predisposing causes.

These general observations serve to indicate the great diversity of causes which may be responsible for an attack of urticaria. In some cases it is difficult, if not impossible, to discover any definite cause, for the habit may have been set up at some remote period, and the most trivial causes may be capable of occasioning a fresh outbreak.

It is customary and convenient to divide the causes of urticaria into two groups, namely, the direct or local causes and the indirect or reflex ones.

I. *Direct or Local Causes.*—(1) *Vegetable Irritants.*—The common nettle (*Urtica urens*) and the variety known as *Urtica dioica* are capable of causing wheals in the most resistant skins. The handling of certain plants which, as a rule, set up an erythemato-vesicular dermatitis, may produce an urticaria; for example, the *Primula obconica*, the poison ivy, and the cowhage.

(2) *Animal Irritants.*—The most common instance of animal irritants causing wheals are the bites and stings of insects; for example, those of fleas, bed-bugs, wasps, gnats, and mosquitoes, and certain caterpillars, such as the common "woolly bear"; the bites of leeches, and the stings of several varieties of jelly-fishes.

(3) *Mechanical and other Irritants.*—Scratching and rubbing readily induce urticaria in a susceptible skin, or when some pruritic affection is present, such as scabies or prurigo; the application of the galvanic current,

as in performing electrolysis for the removal of hairs, is often followed by a wheal; and a lash from a whip, if sharp enough, may cause one.

In some individuals the application of a lintseed poultice will produce wheals, in others dusting with iodoform, or even sponging with boric lotion, will be sufficient to do so, and in highly susceptible patients even the smell of iodoform can cause urticaria. Again, in rare instances, cold air, cold winds, cold water, salt baths and Turkish baths, have all been known to produce it.

II. *Indirect or Reflex Causes.*—(1) *Age and Sex.*—Urticaria may affect either sex, though it is somewhat more common in females. It may occur at any age, but the papular variety may be said to be a disease of early life, while true urticarial wheals are rare in infancy.

(2) *Toxins.*—The most common cause of urticaria is the action of a toxin circulating in the blood, and acting directly or reflexly on the vasomotor mechanism of the skin.

The poison may be in the nature of some drug, such as copaiba, turpentine, quinine, salicin, santonin, iodide of potassium, chloral or morphia, any of which in the smallest dose may cause a profuse urticaria in an individual with the requisite idiosyncrasy towards the drug.

Errors in diet are, however, more frequent causes of urticaria than drugs. The list of articles of diet which may set up urticaria is, of necessity, a long one, since the factor of idiosyncrasy plays such an important part. Among the most common offenders are shell-fish, and especially mussels, crabs, and oysters; oily fish or fish fried in oil, such as sardines, herrings, and eels; certain meats, as pork, veal, and sausages, especially when highly seasoned; fruits, as strawberries, raspberries, dates, and nuts; miscellaneous articles such as cheese, eggs, porridge, and pickles; the ordinary beverages, tea, cocoa, and coffee; and sweet wines such as port, moselle, and champagne.

Urticaria may also occur in association with gout, rheumatism, and malaria, and is due to the circulation in the blood of the respective toxins of these diseases. It not infrequently alternates with attacks of gout and chronic rheumatism, and has been known to replace the cold stage of a malarial paroxysm.

The serums and antitoxins which are employed therapeutically in various diseases may cause urticaria.

(3) *Disorders of other Organs.*—Digestive disturbances, chronic dyspepsia, and the like, may render the patient prone to attacks of urticaria. In infants and children a slight chronic intestinal catarrh may be associated with urticaria, and an outburst of wheals is in such cases liable to take place from such causes as a change of air, injudicious dieting, or the cutting of a tooth. A common cause of urticaria in children is the presence of worms.

Functional and organic disorders of the nervous system may also cause urticaria. Severe emotion, grief, anger, shame, and fright have all been known to do so. It may also occur in connection with neuralgia and locomotor ataxia.

Disorders of the genital system, such as diseases of the ovaries, may be associated with it, and it may occur during menstruation, pregnancy, and lactation, and has been known to follow the passing of a uterine sound. It has also been reported after an enema. Diseases of the liver with jaundice, and diseases of the kidneys with glycosuria and albuminuria, may be complicated by urticaria, and paroxysmal disorders, such as asthma and biliary colic, may alternate or be associated with it. In several instances a reflex urticaria has been reported after the tapping of a pleuritic effusion or a hydatid cyst.

PATHOLOGY.—It is customary to classify urticaria as an angioneurosis, and to define it pathologically as an acute spastic œdema, the result of a vaso-motor disturbance directly or reflexly induced. To a certain extent this definition is adequate, but it is insufficient, as it loses sight of the inflammatory changes which are part of the pathological process.

A wheal, such as that produced by a nettle, if it be excised a few minutes after it appears, presents the following histological architecture :—The capillaries of the skin are dilated, the lymph-spaces, especially in the deeper layers of the corium, are widened, and there is a consequent stretching, attenuation, and sometimes rupture of the fibrous elements of the skin, especially the elastic framework. Around the dilated vessels and lymphatics there is a deposition of polynuclear leucocytes, and sometimes fibrin. The epidermis is not implicated to any extent, and is simply raised up and stretched by the œdematous fluid beneath. But the cellular infiltration does not consist only of leucocytes, there is also a large number of mast-cells, and sometimes a few small connective tissue cells. In other words, the cellular infiltration is similar to that of an acute inflammatory process.

There is at present considerable diversity of opinion with regard to how these histological changes are brought about. It is generally believed that the irritating toxin causes directly or reflexly a spasmodic contraction of the small vessels of the hypoderm—not of the capillaries of the corium, for they do not possess any muscular wall—and that this spasm is quickly replaced by a paralytic dilatation, or by a dilatation the result of a stimulation of the vaso-dilator nerves. This vaso-dilatation is responsible for the initial hyperæmia of the wheal, but associated with it there is an exudation of serum from the dilated vessel, which, by constricting the vessels through pressure, causes the anæmic appearance of the wheal to supervene. The lymph in the skin returns chiefly through the veins, and as these are constricted, it is dammed back, collects, and dilates the spaces in the deeper layers of the corium. When the collection of œdematous fluid becomes excessive the epidermis is also affected, and a vesicle is formed by the fluid collecting either immediately below the epidermis or between the epidermal cells.

PROGNOSIS.—Urticaria is never in itself dangerous to life unless where the mucous membranes are seriously involved, but it may sometimes be an indication, especially in elderly people, of serious underlying organic trouble, such as cancer. In acute urticaria the prognosis is, as a rule, excellent, for when the determining cause has been eliminated the urticaria quickly disappears.

In the chronic type, and in the papular urticaria of infants, the prognosis should be more guarded, as it may take several months, or even years, before the disease is got rid of. The prognosis in these chronic cases largely depends on the recognition of the underlying cause, and in those cases which seem to baffle treatment the difficulty has generally been to discover the cause. In infantile urticaria the ultimate prognosis is generally good, though for several years fresh outbreaks may occur from trivial causes. The disease is frequently worse in hot summer weather, and may disappear entirely during the winter.

DIAGNOSIS.—There is, as a rule, no difficulty in the diagnosis of urticaria, the characters of the wheals being so peculiar as to prevent mistakes. In the giant-type and in the œdematous form affecting the loose skin about the eyelids and genitals, some difficulty may be experienced in distinguishing it from erythema nodosum or gummata. Where it is present in the mucosæ, and occasions symptoms of suffocation or gastric disturbance, it may be difficult to recognise, but the diagnosis can generally be made by the discovery of ordinary urticarial wheals on the skin. The diagnosis of papular urticaria in infants is sometimes far from easy on account of the scratch lesions, excoriations, and pyogenic infections which complicate the eruption. It has to be differentiated from pediculosis, scabies, and where vesicles are present, from varicella. From scabies it is distinguished by the absence of the acarus and its characteristic burrows, and from pediculosis by the absence of the small hæmorrhagic puncta surrounded by an erythematous halo which are peculiar to pediculosis vestimentorum. In varicella, feverishness or other general symptoms are usually present for twenty-four hours before the eruption comes out; these are rare in urticaria papulosa; and in varicella the lesions generally come out first on the trunk, forehead, or face; while in urticaria vesiculosa they are most common on the hands and feet, and ordinary urticarial lesions, or those peculiar to lichen urticatus can, as a rule, be detected elsewhere on the skin.

TREATMENT.—The first essential for the successful treatment of any of the forms of urticaria is to discover and remove the cause of it. Mere empirical formulæ for internal or external remedies are only palliative so long as the causal factor remains. The treatment of urticaria thus varies so greatly in individual cases that it will only be possible to indicate a few of the general lines which should guide the physician in attacking this troublesome condition. For convenience of description the treatment of urticaria may be divided into the internal treatment and the external or local treatment.

Internal Treatment.—In acute urticaria, due to the taking of some drug, such as copaiba or iodide of potassium, the offending drug must be completely stopped, and not simply reduced in dosage. If it should result from a toxin derived from some article of diet, the latter should be eliminated as rapidly as possible. If the patient be seen soon after the eruption has made its appearance an emetic of mustard, zinc sulphate, copper sulphate, or apomorphine may be ordered; if seen later, saline purgatives, such as sulphate of magnesium or sodium, and diuretics are indicated. When the attack of urticaria occurs in association with malaria, quinine should be employed. In the more chronic types of urticaria which are so often connected with gastro-intestinal derangements, it is the latter which most urgently call for treatment. Where chronic gastric catarrh and dyspepsia are present the indigestion should be treated on general principles. The diet must be most carefully regulated. The patient is usually the best judge of what he is capable of digesting. Rich food, pastry, shellfish, potatoes, and strong tea should all be avoided. Beer and sweet wines must be eschewed, and if alcohol be taken at all it had best be in the form of well-diluted spirits or good claret. Hot water may be drunk with advantage the first thing in the morning and before going to bed. The bowels must also be carefully looked after, as the slightest constipation and irregularity may determine a fresh efflorescence of wheals. A sedentary life should be as far as possible avoided, and exercise strongly advocated. The usual gastric sedatives, antiseptics, carminatives, and acid and alkaline tonics, such as bismuth, salol, bicarbonate of soda, dilute nitro-hydrochloric acid, strychnine, and pepsin, should be used where specially indicated.

In cases where the kidneys are acting sluggishly diuretics may prove to be of the greatest value, such as acetate of potash, citrate of potash, and the various alkaline mineral waters such as Vichy, Ems, and Bilin.

Where urticaria complicates chronic rheumatism or gout, salicylate of soda or colchicum will generally give relief, and where it occurs in association with biliary colic or jaundice, the cholagogues, such as podophyllin, rhubarb, and calomel may be resorted to.

Neurotic patients seem to be specially prone to urticaria and, in some cases it is the patient rather than the disease which requires treatment. Nerve tonics, such as strychnine and quinine, may be valuable, but, as a rule, more benefit is obtained from nerve sedatives. The latter diminish the irritation and itching, and what is of most importance in many such cases, insure a night's rest; of these bromide of potassium, phenacetin, and antipyrine have all been recommended. Atropine, either in the form of the tincture of belladonna in pill, or in small hypodermic injections ($\frac{1}{150}$ grain) at night is frequently serviceable, and in the worst cases a hypodermic of morphia may be given. Ichthyol has also been extensively used. It may be prescribed in capsules, 5 ♏ three times a day, or with equal parts of glycerine. Where these measures prove of no avail, the patient is often benefited by a change of air and scenery, rest from some irksome occupation, and the daily regime and amusements of some suitable health resort.

In infantile urticaria the diet must be regulated with the utmost care. It is generally advisable to begin the treatment by administering a saline mixture, and if there be any signs of chronic intestinal catarrh these must be treated on general principles. Intestinal antiseptics, such as salol or small doses of dilute lactic acid, are recommended, and where diarrhœa exists "grey powder" may be prescribed. In children the possibility of the presence of worms should never be lost sight of, and if detected the usual anthelmintics should be ordered. The subjective symptoms are frequently so distressing in infants and children that sleep is interfered with, and the child tosses about, becomes feverish, and by rubbing and scratching aggravates the condition of the skin. In such cases a few grains of chloral at night insures sleep, is easily tolerated, and greatly benefits the patient.

External Treatment.—In all cases of urticaria local treatment is demanded to alleviate the distressing subjective symptoms. In urticaria directly produced it is all that is necessary, but in reflex or indirect urticaria local treatment alone is incapable of curing the affection.

The treatment may be in the form of sponging with various antipruritic lotions, or of sedative baths. The most serviceable lotions are those containing carbolic acid, dilute hydrocyanic acid, subacetate of lead, salicylic acid, tar, turpentine, or camphor, and evaporating lotions of chloroform or rectified spirit. In mild cases the time-honoured calamine lotion, with the addition of 1 per cent of carbolic acid, gives great relief (Calaminæ preparatæ ♏xxx., acidi borici ♏x., zinci oxidi ♏xv., glycerini ♏xx., aquam ad ℥j.); or the following lead lotion may be substituted, Liq. plumbi subacetatis ♏xv., glycerini ♏xx., aquam ad ℥j. Sponging with eau de Cologne or "toilet vinegar" is soothing. In severe cases 2 per cent solutions of carbolic acid in camphor water, or, still better, a 3 per cent solution of the liq. carbonis detergens in water often gives relief.

As a rule ointments and oily substances generally rather aggravate the condition than improve it, but in some chronic cases ointments containing 10 grains of menthol or camphor, or a drachm of chloral to the ounce of soft white paraffin, are beneficial.

In many cases baths seem to relieve the symptoms better than any other form of local treatment. Tepid baths generally give the best results. Alkaline baths containing six ounces of potassium or sodium bicarbonate to thirty gallons of water are particularly soothing. But acid baths with half an ounce of nitric acid, or containing six ounces of borax, or 2 lbs. of starch, bran, oatmeal, or gelatin may be substituted. A thin solution of starch about the thickness of syrup, with the addition of a small quantity of glycerine of borax, has been strongly recommended. After coming out of the bath the skin should be gently but thoroughly dried and dusted with a non-irritating dusting powder such as fuller's earth or starch.

It is necessary to have a large number of local remedies to choose from because different cases react so differently to local treatment.

Where these remedies all fail galvanism may be tried, and it has been known to prove of benefit. The negative pole is applied at the lower end of the spine and the positive pole at the upper.

Besides these local measures the skin should be protected by light warm clothes, irritating underclothing must be dispensed with, and the bed-clothes should be light and the rooms kept cool. Scratching and rubbing should be avoided, but it is useless to tell the patient so unless it can be made possible for him to resist. This is almost impossible in the case of children, but the effects may be rendered less harmful by the wearing of woollen gloves, or by binding on small cardboard splints on the flexor aspects of the arms to keep them fully extended, and in this way to prevent the child from reaching the face or the trunk. Strapping the child down to its crib is not a recommendable measure, as it only tends to intensify the irritation and restlessness.

LITERATURE.—The literature on urticaria is so extensive that it will be impossible here to do more than refer to a few of the important recent communications on the subject. Besides the descriptions in the various text-books on Dermatology, the following recent articles may be consulted, many of which have bibliographies appended:—**Urticaria**: Stephen Mackenzie. *Brit. Journ. of Dermat.* vol. vi. 1894, p. 65.—Colcott Fox. Allbutt's *System of Med.* vol. viii. 1899, p. 485. **Urticaria Chronica**: Jackson. *New York Med. Journ.* July 10, 1897.—Kreibich. *Archiv f. Dermat. u. Syph.* May, 1899. **Urticaria Papulosa**: Colcott Fox. *Brit. Journ. of Dermat.* vol. ii. 1890.—Gebert and Henschel. *Archiv f. Kinderheilk.*, 1891.—Funk and Grundrach. *Monats. f. prakt. Dermat.* vol. xviii. 1894. **Urticaria Factitia, Dermographism**: Stevenson. *Brit. Med. Journ.* January 15, 1898.—Barthelemy. *Étude sur la dermographisme ou dermoneurose toxivasomotrice.* Paris, 1893.—Seymour. Berlin Inaug. Diss. January 1898. **Urticaria Bullosa**: Sidney Carr. *Brit. Med. Journ.* November 10, 1900. **Urticaria Hæmorrhagica**: Stephen Mackenzie. Hunterian Soc. 1892.—Wills. *Lancet*, June 14, 1890. **Urticaria of Mucous Membranes**: Pringle. *Clin. Soc. Trans.* vol. xviii. 1885.—Thilliez de Moncan. *Journ. des sciences méd. de Lille*, October, 1898. **Urticaria of Upper Respiratory Tract**: Merz. *Münch. med. Wochenschr.* September, 1899.—Croce. Breslau, 1900.—Somers. *Med. News*, March 8, 1902. **Urticaria of Larynx**: Woodbury. *Philadelphia Polyclinic*, No. 27, 1898.—Freudenthal. *New York Med. Journ.* December 1898. **Urticaria with Recurrent Hæmatemesis**: Chittenden. *Brit. Journ. of Dermat.* vol. x. 1898. **Urticaria with Albuminuria**: Günzburger. *Münch. med. Wochenschr.* No. 14, 1901. **Pleuritic Urticaria**: Gomez. *Riforma Med.* December 27, 1900.—Minciotti. *Gaz. d. Ospedali e. d. Clin.* November 10, 1901. **Malarial Urticaria**: Zeiss and Rezek. *Allg. Wien med. Zeitung*, No. 46, 1877. **Urticaria from a Wasp-sting**: Parry. *Lancet*, October 26, 1901. **Urticaria following an Enema**: Moorhouse. *Brit. Med. Journ.* May, 1897. **Urticaria with the Formation of Pigment**: Reinhardt. Schmidt's *Jahrbüch*, 1897.—Róna. *Archiv f. Dermat. u. Syph.* July 1898.

Uterus.

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I. Malformations of the Vulva, Vagina, and Uterus.

This subject will be considered under the following headings:—

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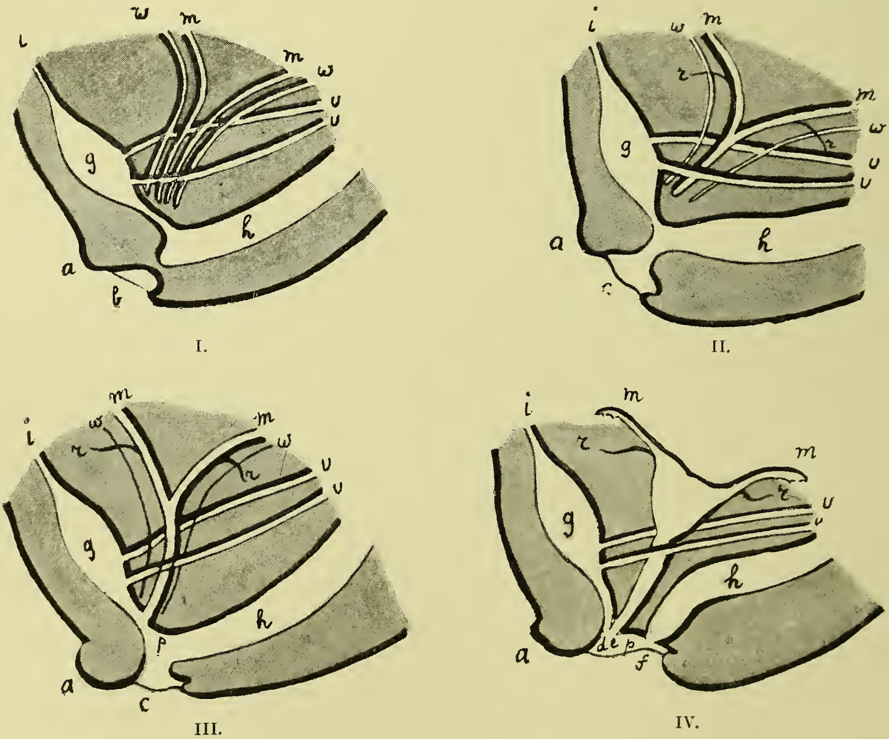
In order to understand the malformations to which the female generative organs are liable, some knowledge of the broad outlines of the development of these organs is necessary.

A. Development of the Genito-Urinary Organs.—Up to the end of the eighth week of fœtal life there is no differentiation of sex (Fig. 1, I.) On each side of the median line is found a Müllerian duct (*m*), a Wolffian duct (*w*), and a ureter (*u*) The allantois (*g*), destined to become the bladder, communicates with the rectum (*h*); there is no communication with the outside, but opposite the end of the hind-gut is a depression (*b*), the urogenital sinus. In front of this depression is a prominence (*a*), the



I. II. III. IV.

Fig. 1.—Diagram of the mode of development of the female genital passages. *a*, Genital eminence; *b*, urogenital sinus, forming, *c*, cloaca, and subsequently, *d*, urethral orifice, *e*, vaginal orifice, *f*, anus; *g*, bladder; *h*, rectum; *i*, urachus; *m*, Müllerian ducts, forming Fallopian tubes, uterus, and vagina; *p*, perineum; *r*, round ligament; *u*, ureters; *w*, Wolffian ducts.

genital eminence, prolonged backwards on each side of the urogenital sinus, and destined to form the external organs. In close relation to the Wolffian duct is a thickening of peritoneum, from which the genital gland (ovary or testis, as the case may be) will be formed.

From the eighth to the twelfth week (II. and III.) important changes occur. The Müllerian ducts coalesce from below upwards (*m*), forming the vagina (which opens below into the urogenital sinus) and the uterus; for some time the uterine horns remain distinct, the demarcation between each horn and its corresponding Fallopian tube being indicated by the insertion of the round ligament (*r*). The Wolffian ducts (*w*) atrophy and finally disappear, except for some vestigial traces still found in the adult (see Table below). The communication between the hind-gut and the outside is effected, forming a cloaca (*c*) which, by the downgrowth of the perineum (*p*) becomes divided into urogenital opening and anus.

From the twelfth to the twentieth week the female characters become more marked (IV.) The uterine horns become fused to form an undivided uterus; the cervix with its arbor vitæ is indicated; the urethral and vaginal orifices become separated (*d* and *e*); the perineum (*p*) enlarges, separating the anus (*f*) farther from the vaginal orifice. The genital eminence (*a*) becomes relatively smaller, forming the clitoris; the folds which pass backwards from it, bounding the urogenital sinus, become the labia minora, and within the vestibule between them the hymen forms round the vaginal orifice. From the twentieth week to the end of fœtal life the organs already formed become better developed; the fundus of the uterus increases in size, though it does not keep pace with the size of the cervix; folds form in the vagina and cervix, and the labia majora become fuller and more rounded.

From birth to puberty the body of the uterus gradually enlarges till it becomes larger than the cervix, and the vulva increases in size.

It would take us beyond the scope of our subject to trace in detail the development of the genital organs in the male; but it is important to remember that they arise from the same primitive structures as are found in the female; and this fact explains the phenomena of pseudo-hermaphrodism. The relation of the adult organs in the male and female, and their common derivation from the same fœtal structures, are indicated in the following table, the parts shown in italics being rudimentary or vestigial in the adult:—

A Table of Homologous Parts in the Male and Female

Adult Male.	*Fœtal Structures.*	*Adult Female*
Body of testis	Genital gland	Oöphoron
Paradidymis Vasa efferentia	Wolffian body	Paroöphoron *Parovarium (epoöphoron)*
Vas deferens	Wolffian duct	*Duct of Gartner*
… … *Sinus pocularis*	Müllerian duct	Fallopian tube Uterus Vagina
Corpora cavernosa (penis) Corpus spongiosum (penis)	Genital eminence and folds prolonged backwards from it	Corpora cavernosa (clitoridis) Glans clitoridis and vestibular bulbs.
Prostatic urethra Membranous urethra Folds at entrance to sinus pocularis Cowper's glands	Urogenital sinus	Urethra Vestibule Hymen Bartholin's glands
Scrotum	Outer portion of genital folds	Labia majora

B. Malformations.—From a consideration of the facts of development, as we have briefly outlined them, it will be readily understood that malformations may occur in three ways:—

I. Arrest of development, partial or total, of individual portions.

II. Persistence of septa, longitudinal or transverse, which should normally disappear.

III. Excess of development of individual portions.

We shall describe the malformations of the genital organs in the order indicated.

I. Arrest of Development.

(*a*) *Total Arrest, or Suppression.*—*Absence of the genital organs* is found only in the case of gross monstrosities, and is therefore very rare.

Absence of the vulva is also a very rare condition. The labia minora or majora may be absent; but even then some trace of the clitoris is nearly always found. The internal organs in such cases are generally underdeveloped.

Absence of the vagina sometimes occurs. The interval between cervix and vulva is then occupied by a fibrous thickening or cord-like band, which is all that remains of the vagina. The urethra comes to lie nearer the anterior rectal wall than usual.

Absence of the uterus is said to occur even when a vagina is present; but this is very doubtful, as some trace of the uterus, however small, is usually found on dissection. Clinically it is very difficult to determine whether the uterus is absent or not. The same remarks apply to absence of one or both of the ovaries and tubes.

Absence of the anterior or posterior wall of the urethra may occur, producing the conditions known respectively as epispadias and hypospadias.

(*b*) *Partial Arrest of Development, or Under-development.*—*Under-development of the whole genital organs* is not very infrequent; and all grades are found, corresponding with arrest of growth at various stages from birth to puberty.

Under-development of the Vulva.—Individual portions may be concerned, such as the clitoris, labia minora, or labia majora. In the condition known as *exstrophy of the bladder,* in which the abdominal wall from the umbilicus to the urogenital sinus (*i* to *b,* Fig. 1, I.) fails to unite, the clitoris is usually bifid and rudimentary, and the labia minora are also small. Or the whole vulva may be small and infantile.

Partial Absence of the Vagina.—The lower or middle part of the vagina is sometimes absent, whilst the upper portion is patent. The deficient part is represented by a fibrous cord. This condition is referred to more fully later in discussing atresia of the genital passages.

Under-development of the Uterus.—This may be present in one of two degrees:—

Rudimentary Uterus.—The uterus may be represented only by a little knob or button surmounting the vagina; or the cervix may be fairly well marked, whilst the body of the uterus is very narrow, and the Fallopian tubes meet at the fundus. Menstruation is absent; and the secondary sexual characters, such as the breasts and pubic hair, are usually poorly developed. The patient may show general arrest of development, the woman of twenty-five presenting the physical and mental characteristics of a child.

Infantile Uterus.—In this case the body of the uterus preserves the characteristics of childhood; it is small, with an ill-developed fundus; and the cervix may be two or three times the length of the body. Menstruation seldom occurs; or it comes on very late and is scanty and irregular. The vulva, vagina, pubes, and breasts may share in the retardation; but on the other hand they may not differ from the normal adult condition. Sexual desire is usually absent.

Uterus Unicornis.—If one-half of the uterus develops normally whilst the other retains its fœtal condition, the condition known as uterus unicornis or one-horned uterus results (Fig. 2). The round ligament marks the limit between the rudimentary horn and the Fallopian tube. Both tubes and ovaries may be normal; but more often the tube and ovary remain rudimentary on the side of the undeveloped horn. The condition may give rise to no symptoms and remain undiscovered, the normal half of the uterus carrying on the functions of menstruation and gestation. Pregnancy may, however, occur in the rudimentary horn, giving clinically the symptoms and signs of a tubal gestation.

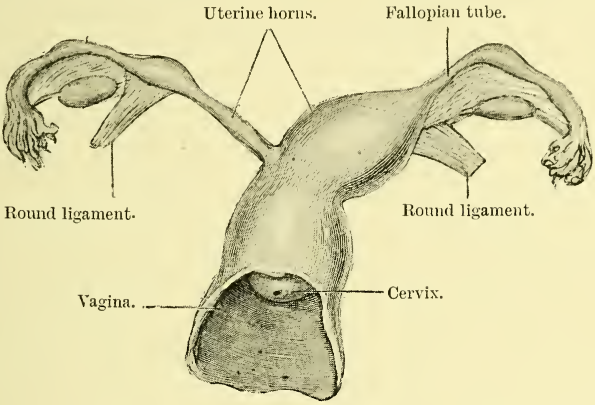


Fig. 2.—Uterus unicornis.

Rudimentary Fallopian Tubes.—One or both tubes may remain underdeveloped; sometimes this is the result of fœtal peritonitis. In rare cases, of which we have seen an example, the tubes become occluded along their course and divided; the fimbriated end shrivels up, and the remainder of the tube comes to resemble closely a vermiform appendix. In other cases the fimbriæ remain well developed, whilst the portion of tube nearer to the uterus atrophies to a cord-like structure.

Rudimentary ovaries usually present the long, narrow shape characteristic of fœtal life; and this form is seen not infrequently in cases of undescended ovary and of congenital hernia of the ovary. In other cases the ovary has the normal shape, but is small. Menstruation and sexual desire may be absent; and in any case sterility results.

As the result of arrest in the development of the cloaca and urogenital sinus several rare malformations occur. Thus the anus may be imperforate terminally, the rectum opening into the posterior wall of the vagina; conversely the vagina may be imperforate below, but open into the anterior rectal wall. The urethra may be absent, the bladder opening into the anterior vaginal wall. There is an example in the museum of the London Hospital of rectum and bladder both opening into the vagina, the orifice of which thus served as a general cloaca. There was apparently no suspicion of the state of things till the patient was ordered an enema in the hospital.

II. Malformations due to the Persistence of Septa.—A persistent septum may be longitudinal or transverse, or there may be a combination of both conditions; and three types of malformation are thereby produced :—

(*a*) Double uterus and vagina, from failure of coalescence of the two Müllerian ducts.

(*b*) Atresia of the genital canal, from failure on the part of the coalesced Müllerian ducts to open into the urogenital sinus.

(*c*) Doubling of the uterus and vagina with atresia in one-half, that is, unilateral atresia.

(*a*) *Double Uterus and Vagina.*—Inasmuch as the fusion of the Müllerian ducts occurs from below upwards, it is not uncommon to find a double uterus with one vagina, or a double fundus with a common cervix and vagina; but the reverse condition, that is to say, a double vagina with undivided uterus, or double cervix with undivided fundus, is never found.

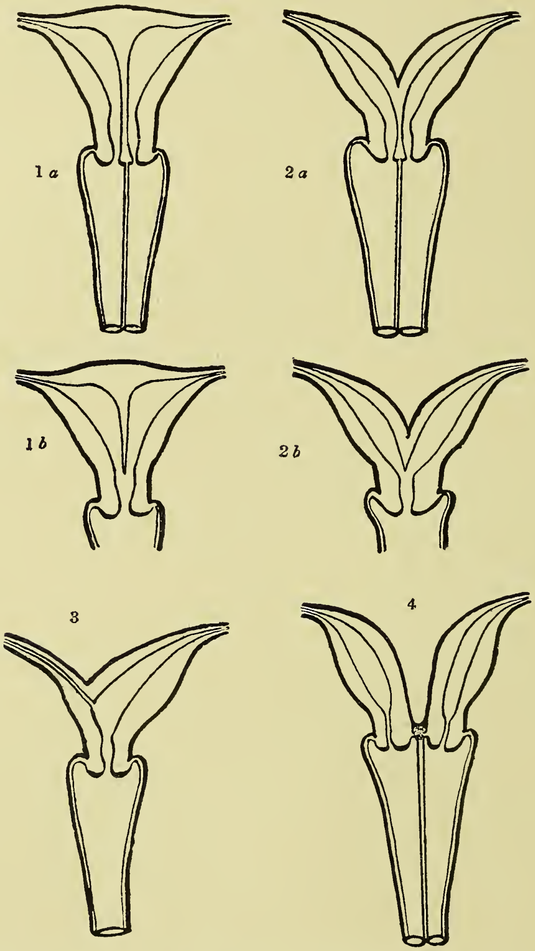


Fig. 3.—1 *a*, Uterus septus; 2 *a*, uterus bicornis; 1 *b*, uterus subseptus; 2 *b*, uterus bicornis unicollis; 3, uterus unicornis; 4, uterus didelphys.

Double Vagina.—This condition occurs in some cases of double uterus. The septum between the two halves of the vagina may extend to the vulva, when the appearance of the vaginal orifices somewhat resembles a double-barrelled gun. Or the orifice may be single, and the septum is discovered only on making a digital examination. The septum itself may be quite complete; or it may be perforated in parts; and in some cases it is incomplete, and represented by longitudinal ridges on the anterior and posterior vaginal walls.

Double Uterus.—Three types are found: the uterus septus, the uterus bicornis, and the uterus didelphys. In the first two the cervix may be single or double, but the uterus didelphys has necessarily two cervices.

Uterus Septus (Fig. 3, 1 *a* and 1 *b*).—Here the Müllerian ducts have fused externally, so that when seen from the outside the uterus appears normal save for some broadening of the fundus. But on section a partition is seen extending from the fundus to the os externum or even to the vaginal orifice (Fig. 3, 1 *a*).

In the variety known as *uterus subseptus* (Fig. 3, 1 *b*) the septum reaches only to the os internum, so that the body of the uterus is double, whilst the cervix and vagina are single.

Uterus bicornis (Fig. 3).—In this case external union takes place in the lower part of the uterine body and cervix, but is wanting at the fundus, so that externally this portion of the uterus appears as two horns. The septum extends throughout the cervix, which is also double, and may reach the vaginal orifice (Fig. 3, 2 *a*). The demarcation between uterine horn and Fallopian tube is indicated by the insertion of the round ligament.

Uterus Bicornis Unicollis.—This is a variety of the preceding type, and cannot be distinguished from it externally. The septum reaches only to the os internum so that the cervix and vagina are normal (Fig. 3, 2 *b*). A vaginal examination will, of course, enable one to distinguish between a uterus bicornis and a uterus bicornis unicollis, or between a uterus septus and a uterus subseptus.

Uterus unicornis, already referred to, is of course also a variety of the uterus bicornis, in which one horn has remained undeveloped (Fig. 3 (3)). It is therefore a combination of the two main types of malformation which we have indicated, namely, partial arrest of development with persistence of a septum.

Uterus Didelphys (Figs. 3 (4) and 4).—In this form the two halves of the uterus remain quite distinct, and can be moved independently of one another. The vagina is always double, the two halves being united by connective tissue, and a loose bridge of connective tissue usually extends between the two cervices. A well-marked fold of peritoneum passes between the two uteri from the back of the bladder to the front of the rectum. Each half of the uterus has its own Fallopian tube and ovary, and the round ligament shows where uterus ends and tube begins. One-half of the uterus may be considerably displaced, so that it comes to lie in front of the other.

(*b*) *Atresia of the Genital Canal.*—Congenital atresia only affects the vagina. Clinically atresia of the os externum or internum is also found, but it is secondary. We shall, however, consider all kinds of atresia when discussing the clinical significance of malformations.

Vaginal atresia is of various grades. In the simplest form a thin septum is present, occluding the vaginal orifice. This was formerly called atresia of the hymen; but the septum is vaginal, and on its external surface the hymen is found adherent. For it must be remembered that the hymen is not a complete diaphragm at any stage of its development; it arises as a membranous fold from the margins of the urogenital sinus.

The vagina may altogether fail to reach the surface, so that its lower third, or half, or even the whole of it may be absent. There is nearly always, however, some portion of it unoccluded just below the cervix. When the lower two-thirds are wanting, the apex of the upper patent portion is connected with the vestibule by a fibrous cord; and this may fail to elongate as the pelvis grows, with the result that the vestibule is drawn in so as to form a *cul-de-sac* resembling the lower part of the vagina. It is very doubtful if a portion of true vagina is ever present externally when the middle or upper part is wanting; in other words, it is doubtful if the Müllerian duct persists at its lowest part and opens into the vestibule whilst a portion higher up is suppressed.

Atresia of the Fallopian tubes has been referred to; it is not a true congenital (*i.e.* developmental) atresia, since it is the result of disease in the fœtus.

In all forms of persistent septa, whether longitudinal or transverse, the patient is otherwise well developed as a general rule. Longitudinal septa are compatible with the performance of genital functions, menstruation, conception, and pregnancy. Atresia is a bar to conception; but menstruation may occur, although its products are necessarily retained.

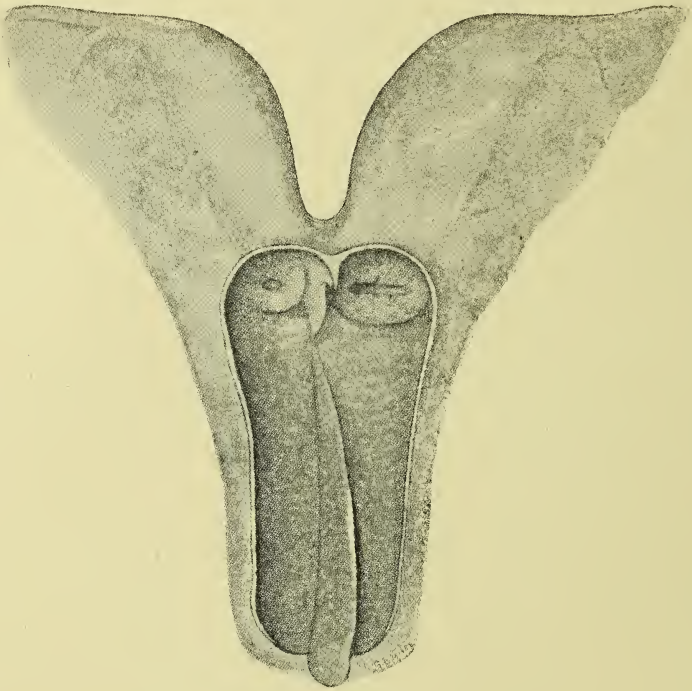


Fig. 4.—Uterus didelphys.

(*c*) *Unilateral Atresia.*—In cases of double uterus and vagina coalescence may fail to take place not only longitudinally, but also terminally, so that one vagina may run down by the side of the other as a blind sac. Hence, while one-half of the uterus and vagina may appear, clinically, to be normal, retention of menstrual products may occur in the other half. Similarly in cases of double uterus with a single vagina, one-half of the uterus may have no opening into the vagina; and if this half of the uterus menstruates, as usually occurs, its products will be retained.

III. Malformations by Excess of Development.—*Hermaphrodism* means the development of both male and female generative organs in the same subject, and occurs in some of the lower animals. The presence of both ovary and testis is necessary in order that a case may be regarded as one of true hermaphrodism, and this condition has not been demonstrated in the human species.

Pseudo-hermaphrodism means the development in the same subject of male and female accessory genital organs, including in this term everything except ovary and testis. Pseudo-hermaphrodism is found in the human species, and is of two principal types:—

Gynandria, in which the subject is a female and possesses ovaries, but has also accessory organs resembling the penis and scrotum of the male.

Androgyna, in which the subject is a male and possesses testicles, but has also the accessory organs of a female, such as vagina, uterus, and Fallopian tubes. The penis may be undeveloped, resembling a clitoris; and the two halves of the scrotum may fail to unite, resembling labia majora. It is often very difficult, and in some cases impossible to say whether an individual is male or female; for nothing but a microscopical examination of the genital gland, to determine whether it is an ovary or a testis, will decide the point. As a matter of fact, most cases of pseudohermaphrodism are really males, and these we are not here concerned with.

In gynandra the clitoris is large, like a small penis, and the labia majora fuse in the middle line, resembling the scrotum. The resemblance is all the more striking if the ovaries are herniated into the labia majora. In such a case the vagina, which is generally small, opens into the urethra at the root of the clitoris like a hypospadiac male; the uterus may be fairly well developed. A typical case of this malformation was the now historical one of Madeline le Fort.

Hypertrophy of the clitoris may occur independently of pseudohermaphrodism, and it may be difficult to distinguish this condition from a benign new growth.

Hypertrophy of the Labia Minora.—These are minor degrees of enlargement which are in no sense congenital, and which are due in some cases to masturbation. Elongation may, however, be excessive, as is typically seen in the Bush-women of South Africa, giving rise to the condition known as the Hottentot apron.

Congenital elongation of the cervix affects the vaginal portion, which may attain a length of 2 to 3 inches, and project through the vulvar orifice. This condition is seldom observed till puberty, so that it is difficult to say whether it is always present from the time of birth, or whether it is incidental to the general enlargement of the pelvic organs that takes place at puberty.

Accessory Ostia Tubæ.—The Fallopian tube is sometimes found with two or even three fimbriated openings. The condition has no clinical importance.

A third or accessory ovary has been described, and some writers state that this is a common occurrence. "A careful consideration of the evidence makes it clear that small pedunculated bodies near the ovary are very frequent, but they are not accessory ovaries. Many of them are partially detached tubes of the parovarium, stalked corpora fibrosa, or small myomata of the ovarian ligament. So far as the facts stand at present, a supernumerary ovary, so separated from the main gland as to form a distinct ovary, has yet to be described by a competent observer" (Bland-Sutton and Giles).

Defects of the Hymen.—The hymen is subject to variations in shape and in structure. The orifice is normally crescentic, concave anteriorly; instead of this the aperture may be central and circular, or it may be divided so that two apertures exist, either one in front of the other or side by side. In the latter condition the appearance closely resembles that of double vagina, from which it must be distinguished. The *cribriform hymen* presents a number of openings.

In structure the hymen may be distensible and yielding, allowing coitus to occur without rupture; or it may be dense and unyielding, requiring division before coitus can take place. In rare cases the hymen has persisted during pregnancy, and formed an obstacle to labour.

C. Clinical Aspects of Malformations of the Female Genital Organs.—1. *Symptomatology.*—It will be convenient to consider here the various malformations in relation to the general bodily and mental development, to the secondary sexual character, to menstruation, and to child-bearing.

Absence of the genital organs is only found, as we have said, in the case of monstrosities. With marked under-development of the uterus and ovaries—for instance, with rudimentary uterus or infantile ovaries—there are often found retarded physical growth and imperfect mental powers. Slight degrees of under-development are compatible with an otherwise well-formed body and a vigorous mind. The same may be said of malformations in the second and third groups, namely, doubling and atresia of the genital passages and hypertrophy of vulva or cervix. The development of the secondary sexual characters maintains a fairly close parallel with that of the pelvic organs, so that when the latter are imperfectly formed we find the breasts flat, small, and even absent, the pubic hair scanty or absent, as in the case of a child, and the vulva small.

Menstruation is established late or not at all when the uterus is under-developed. A woman with a rudimentary or infantile uterus, or with imperfect ovaries, does not menstruate. Broadly speaking, the occurrence or otherwise of menstruation gives a fairly reliable indication of the degree of development, whilst its characters, where it does occur, also have their significance. If menstruation is normal it may be presumed that there is not any considerable arrest of growth; if it is very scanty and irregular, and if it comes on late, it can generally be assumed that some degree of under-development exists.

In the case of double uterus menstruation has nearly always the normal characters, and even if one-half be under-developed, as in the uterus unicornis, the other half is generally functional. In cases of atresia the changes incidental to menstruation occur in the uterus, but the menstrual products are of course retained (*cryptomenorrhœa*). When distension of the vagina comes on symptoms arise, chiefly in the form of abdominal pain, which has at first a monthly exacerbation, but later on becomes more or less constant. In cases of unilateral atresia the symptoms may be misleading, because the retention of products in the occluded half of the vagina and uterus produces the characteristics just described, whilst menstruation is apparently taking place normally on the other side.

Effects of Retention of Menstrual Products in Cases of Atresia.—According to the situation of the obstruction and the duration of cryptomenorrhœa the following conditions may result, shown diagrammatically in Fig. 5:—

(i.) *Atresia of the Vaginal Orifice.*—As first mentioned, blood collects in the vagina, producing the condition known as *hœmatocolpos* (Fig. 5 A). In the course of time distension occurs successively in the cervix—*hœmatotrachelos* (B), in the body of the uterus—*hœmatometra* (C), and in the Fallopian tubes—*hœmatosalpinx* (D).

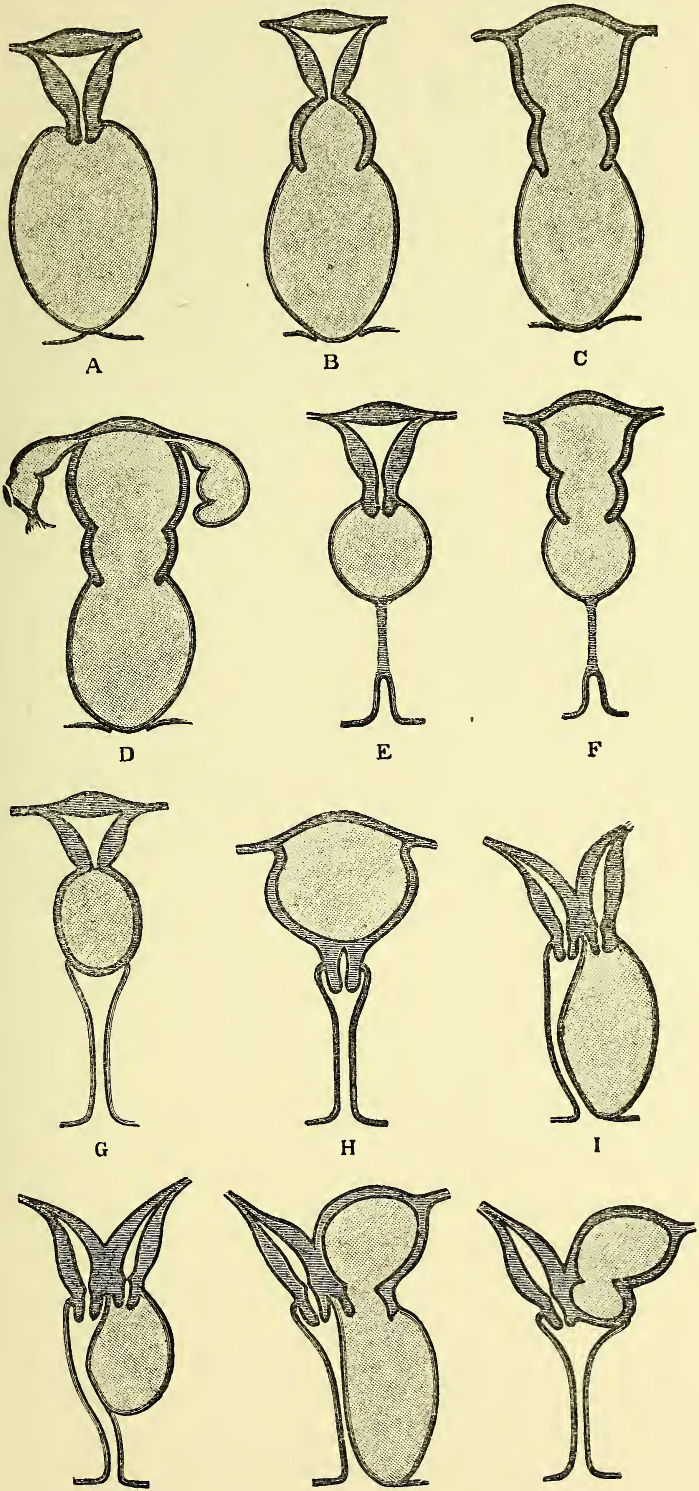


Fig. 5.—The effects of atresia on the genital passage.

(ii.) *Absence of the Lower Part of the Vagina.*—The distension proceeds in the same order as above, affecting first the vagina (E), and then the uterus (F). No indication of the distension is, however, seen at the vulva, whilst in the preceding group the vaginal septum bulges down between the labia.

(iii.) *Atresia of the Os Externum.*—Here the vagina remains normal, and the cervix suffers (Fig. 5 G), and then the whole uterus.

(iv.) *Atresia of the Os Internum.*—The cervix and vagina both remain free, and a pure hæmatometra is formed (H). The last two conditions are seldom if ever congenital.

(v.) *Atresia Affecting One-half of a Double Uterus or Vagina.*—When one vagina is occluded *lateral hæmatocolpos* at first results, the swelling extending by the side of the normal vagina down to the vulva (I), or only part of the way if the occluded vagina is also partly deficient (J). Hæmatometra follows (K), or it occurs alone if the atresia affects the os internum (L).

If the contents of these various retention-sacs suppurate, either spontaneously or through a temporary fistulous aperture, pyocolpos, pyometra, and pyosalpinx may occur.

Characters of retained Menstrual Blood.—This is a dark chocolate colour, sometimes black. It is viscid, owing to partial absorption of the liquid portion of the blood, and flows slowly, like treacle or honey. It is mixed with mucus, and seldom contains coagula. Cholesterin crystals are sometimes found. Microscopical examination shows the presence of old and altered epithelial cells and blood corpuscles in various stages of decomposition.

Child-bearing in Relation to Malformations.—When the pelvic organs are under-developed sexual desire and feeling are frequently absent or only slightly present. Desire probably depends more upon the development of the ovaries than upon any other individual factor; but sexual feeling during intercourse will also vary according to the degree of development of the vagina and vulva. Child-bearing does not, however, depend upon sexual inclination or sensation, but upon the production of healthy ova, the ability of the uterus to nourish an ovum, and the possibility of coitus taking place. Under-development of the ovaries leads to complete and permanent sterility. Under-development of the uterus has the same effect, both because it is usually associated with defective ovulation, and because the uterus is unfit for pregnancy. A woman with a double uterus is very often fertile, and several pregnancies may occur without the malformation being even suspected. Complications with labour may, however, occur. Sexual intercourse is possible as long as the vagina is well enough developed, whatever be the condition of the internal organs: the conditions which prevent coitus are absence, atresia, or stenosis of the vagina. In pseudo-hermaphrodism the vagina is usually small. If a case of atresia of the vagina be treated early coitus can take place, and, theoretically at least, may be followed by conception; but if considerable changes have taken place owing to distension before the obstruction is removed it is doubtful whether the patient could conceive. We have not met with or heard of a case where a patient who had had atresia of the vagina became pregnant subsequently.

2. *Diagnosis.*—The diagnosis of malformation will depend in the first place on inspection, when any external abnormality will be at once discovered, and the patency or otherwise of the vaginal orifice determined. A digital vaginal examination will show whether the vagina is unduly

narrow or short, or whether the cervix is normally developed. Two vaginæ may be thus discovered, each containing a cervix; or two cervices may be found in a single vagina. Bimanual examination will then be necessary to determine the degree of development of the uterus, tubes, and ovaries. This information can also be obtained, though less satisfactorily, by a recto-abdominal examination. The sound will lend assistance in ascertaining the length of the uterus, and may also enable one to demonstrate that the uterus has two cavities. The uterus may be found to be very small or rudimentary, and it may even be impossible to feel it at all bimanually. When the ovaries are small they are often difficult to feel, and it may not be possible to form any conclusion as to their development except by inference. Unilateral atresia often presents great difficulties in diagnosis; a lateral hæmatocolpos will resemble an abscess burrowing down by the side of the vagina, whilst a lateral hæmatometra will probably be mistaken for a broad ligament or ovarian cyst until the condition is ascertained by operation, or on the post-mortem table.

3. *Treatment.*—The scope of treatment for malformations of the female genital organs is necessarily limited. When there is under-development of uterus and ovaries no treatment is of any avail; and in cases of doubling of the uterus and vagina no treatment is necessary, unless it be that the vaginal septum interferes with intercourse or obstructs labour; in which case it should be divided, and, if possible, either a portion or the whole length of it excised. If the clitoris or labia are so enlarged as to cause discomfort, or if the cervix is much elongated, resection of the part is indicated.

The conditions that more particularly call for treatment are different forms of atresia and of absence of the vagina. Thus hæmatocolpos will require a free incision to allow of the evacuation of the retained fluid. The treatment of hæmatometra, with a normal vagina, is equally simple; but special means must be taken to prevent reclosure, as by packing with gauze, and by the use of dilators later on if necessary. Absence or considerable deficiency of the vagina is a more difficult matter to deal with. Treatment may be required either to allow of the outflow of menses or to permit of intercourse. Dissection may have to be carried to some depth between the urethra and rectum before the blind end of the vagina or the cervix is reached; and when this has been done it is a very troublesome matter to keep the channel patent. Various plastic operations, with the turning in of flaps of skin, have been suggested and practised from time to time; in a few cases a successful result has been attained, it may be after repeated operations. In other cases the attempt has had to be abandoned, and it has been found necessary to perform abdominal hysterectomy to prevent the recurring hæmatometra. Lateral atresia requires to be treated on the same principles as the more common forms of atresia; it is important that the septum between the patent and the occluded half of the vagina or uterus should be removed as far as possible to prevent reclosure.

Occluded tubes usually require removal; but in some cases it is possible to restore the patency of a tube by a plastic operation.

Mere stenosis of the vagina or rigidity of the hymen is easily treated by dilatation of the former or incision of the latter. Some care in the after-treatment will probably be required to maintain the normal calibre.

II. Displacements of the Uterus

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The Normal Mobility of the Uterus. — The most rigid attachments of the uterus are those of the supravaginal portion of the cervix. Here the uterus is inserted in the pelvic floor, and is embraced by the pelvic fasciæ. In front it is attached for a distance of 2 cm. to the posterior wall of the bladder; by the utero-vesical ligaments, it is attached to the pubes. Behind it is attached to the sacrum by the utero-sacral ligaments which contain strong muscular bands in their folds. These ligaments converge to form the muscle of Luschka, and are inserted into the posterior aspect of the uterus at a point a little below the junction of body and cervix.

These attachments make the supravaginal portion of the cervix the part of the uterus which is least movable. Above, the body of the uterus is comparatively free, while below, the vaginal portion is entirely unattached, consequently the upper segment of the cervix uteri becomes the axis of rotation of its antero-posterior movements. It may also be called the point of suspension of the uterus, because if any ligaments are concerned in the support of that organ these are the utero-sacral.

The attachments of the body are loose. The round ligaments are "attached to the upper angles of the uterus on either side immediately in front of the Fallopian tube. From this point each ligament proceeds upwards and forwards to gain the inguinal ring; and after having passed, like the spermatic cord in the male, through the inguinal canal, reaches the fore part of the pubic symphysis, where its fibres expand and become united with the substance of the *mons veneris*. Besides areolar tissue and vessels, the round ligaments contain plain muscular fibres like those of the uterus, from which, indeed, they are prolonged" (Quain). They thus permit of an antero-posterior range practically from pubes to sacrum.

The folds of peritoneum, which form the broad ligaments, pass outwards and backwards to the sides of the pelvis in front of the sacro-iliac joint; they permit the body of the uterus to be moved from one side of the pelvic inlet to the other.

Normal Movements and Positions of the Uterus.—The position which the uterus occupies depends chiefly on the amount of distension of the bladder and rectum for the time being. When the bladder is distended the uterus is pushed into retroposition or retroversion. When the rectum is distended and the bladder is empty the uterus becomes anteposed. When bladder and rectum are both distended, the uterus is elevated. The uterus also moves upwards and downwards with every respiration. These displacements may be considered normal, because they are temporary and due to physiological acts. Strictly speaking, the uterus has no fixed normal position, but the position which it takes up when the bladder and rectum are empty may, for gynæcological purposes, be considered the normal one, as these organs are emptied before an examination is made; then the uterus is anteverted, placed as far forward as the bladder will allow, turned a little to the right, and, when the woman stands erect, is nearly horizontal, being perpendicular to the long axis of the vagina. The fundus is in the plane of the pelvic brim. When the woman is erect and the uterus is in this position all its ligaments, with the exception of the utero-sacral, have their origins and insertions at the same level, and are therefore in no sense suspensory. "The uterus," to quote Alexander, "floats, as it were, in the midst of structures of a specific gravity not much less than itself," and the ligaments simply poise or steady it. When the body is pushed back to the physiological limit, the round ligaments restrain the movement and prevent dislocation of the fundus below the sacral promontory.

The utero-sacral ligaments differ from the others—their uterine attachment occupies a lower level in the pelvis than their insertion into the sacral vertebræ. The ligaments may therefore be called suspensory. They also keep the cervix towards the sacrum, and along with intra-abdominal pressure are the chief factors in maintaining the normal anteversion of the uterus (Fig. 1).

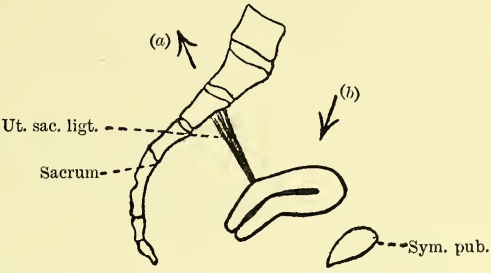

Fig. 1.—(*a*) Represents action of ut. sac. ligt.; (*b*) intra-abdominal pressure.

Abnormal Positions of the Uterus.—1st. *Displacements of the Uterus as a whole.*—We have seen that the organ may be elevated, retroposed, or anteposed as a whole by physiological causes. The mobility of the uterus also permits these changes of position to occur as the result of pathological agencies which render the displacement permanent. For example, *ascent* may be caused by adhesions drawing up the uterus or by tumours pushing it up from below and fixing it permanently in its abnormal position. In like manner *retroposition* of the uterus may be brought about by adhesions posteriorly drawing it and fixing it towards the sacrum, or by tumours situated in front of the uterus pushing the organ back. *Anteposition* may be caused by adhesions in front drawing the uterus forwards, or by tumours behind pushing it against the pubes.

The mobility of the uterus is also such that by fixing a volsella in the cervix one can draw it down to the vulva. This descent occurs pathologically, as when the uterus is pushed down from above by intra-abdominal pressure or by tumours as in prolapsus uteri. The lateral mobility of the uterus is normally less than in other directions, still it allows of that organ being drawn to one side of the pelvis by contractions or adhesions, or of being pushed there by tumours.

2nd. *Displacements of the Uterus by Version.*—In version the uterus rotates (1) Round an imaginary transverse axis with its fundus forwards and cervix backwards constituting anteversion, or with the fundus backwards and the cervix forwards Retroversion; (2) Round an imaginary antero-posterior axis with the fundus to one side of the pelvis and the cervix to the opposite side—Lateriversion.

3rd. *Displacements of the Uterus by Flexion*, by which the relative position of body and cervix is altered. The normal uterus is flexible. Intra-abdominal pressure acting on the upper surface of the uterus (Fig. 1) causes the body to bend forwards on the cervix—the angle found at the junction of body and cervix constitutes the normal anteflexion of the uterus. This normal anteflexion may be increased as in congenital and pathological anteflexion, or the axis of the uterus may become straight as in anteversion. The body is bent over on the posterior aspect of the cervix in retroflexion, and to one or other side in lateriflexion.

4th. *Inversion of the Uterus.*—In this displacement the form of the uterus is altered by its inner surface being turned outwards and its outer surface inwards.

1. Ascent of the Uterus.—The uterus ascends normally during pregnancy. After the fourth month it becomes an abdominal organ. Various diseased conditions of the uterus and surrounding parts cause its ascent; the body may be so much enlarged by a fibroid tumour that it thereby becomes elevated, or a fibroid may grow downwards from the uterine cavity into the vagina and from its size lift up the organ. Vaginal neoplasms and the condition known as hæmatocolpos act in a similar manner. Ovarian, parovarian, and broad ligament tumours, cystic or solid, may, so long as their size keeps them in the pelvis, act similarly. A tube enlarged by extra-uterine gestation, a collection of blood, serum, or pus in the pelvis, either encapsulated or not, may have the same effect.

When the uterus has been elevated into the abdominal cavity by some of the causes already mentioned, and an attack of peritonitis supervenes, it may become permanently fixed in that position. In this, as in every case, the treatment is that of the cause producing it.

2. Descent of the Uterus.—Descent of the uterus occurs in retroversion and retroflexion. In these affections the uterus occupies a lower position in the

pelvis than normal. When the uterus descends so low that the vaginal portion protrudes through the vulva, it is said to be prolapsed.

3. Prolapse of the Uterus.—The abdominal viscera, the uterus and its appendages are, when normal, in a state of equilibrium. The abdominal cavity is always full, and intra-abdominal pressure is exerted in all directions; but in the erect posture that pressure, along with gravity, is directed anteriorly against the anterior abdominal wall and the back of the pubes. Inferiorly it is directed against the sacral segment of the pelvic floor. Anteriorly this pressure is counteracted by the resistance of the anterior abdominal wall. Inferiorly the pressure is counteracted by the resistance of the sacral or fixed segment acting at right angles to it.

If from any cause this equilibrium is disturbed, if there is increased intra-abdominal pressure, or weakening of the anterior abdominal wall or pelvic floor, we get protrusions of the nature of herniæ—herniæ of the abdominal wall or the pelvic floor. In the former the herniæ usually occur at the umbilicus, inguinal or femoral rings. In the latter it is the displaceable segment of the pelvic floor that is herniated.

This displacement of the Pelvic Floor is commonly but erroneously called prolapse of the uterus. Certainly the uterus becomes prolapsed, but as it has nothing to do with the causation of the displacement, taking only a passive part from the fact of its being attached to the portion of the pelvic floor that becomes displaced, it is more correct to call the affection displacement of the pelvic floor.

The affection is essentially a hernia of the displaceable segment of the pelvic floor. The size of the uterus has nothing to do with it. This displacement occurs when the uterus is smaller than normal. Enlarged uteri may become and often do become retroverted, as in subinvolution, or anteflexed as in pregnancy, but one does not get displacement of the pelvic floor on account of the increased size of the uterus.

Displacement of the displaceable segment of the pelvic floor, and the accompanying prolapse of the uterus, is caused by (*a*) increased intra-abdominal pressure; (*b*) weakening of the sacral or fixed or supporting segment of the pelvic floor; and (*c*) deficient tone of the anterior segment of the pelvic floor.

Intra-abdominal pressure is increased when the abdomen is distended by tumours or by fluid; it also results from tight lacing and from the habit some women have of supporting heavy clothing on bands fastened round the abdomen. It is likewise caused by strong and prolonged muscular exertion, and is induced by the repeated expiratory effort of cough in chronic bronchitis.

The resistance of the supporting segment of the pelvic floor is impaired by parturition, which causes the segment to be straightened out or torn. One often meets with cases, however, where the perineum is completely divided, and yet the uterus retains its normal height in the pelvis. In such a case the remainder of the pelvic floor is sufficiently strong to maintain equilibrium.

Deficient tone of the displaceable segment of the pelvic floor is also a result of parturition. For some time after labour this portion of the pelvic floor may be said to have lost its tonicity, and if a woman rises too soon, that is before its normal strength has been restored, intra-abdominal pressure will force the parts down and produce herniation. This descent is favoured by the lax and toneless condition of the utero-sacral ligaments, and may occur when the sacral segment is unbroken and its power of resistance unimpaired. In old women the whole pelvic floor may be wanting in tone, and a slight increase of abdominal pressure may cause the displacement. And, conversely, the resistance of the entire pelvic floor may be normal, but the intra-abdominal pressure may be so enormously increased, as when the abdomen is occupied by large tumours, that the whole displaceable portion may be forced out of the pelvis.

The order in which the placed structures appear at the vulva is as follows:—The lower end of the anterior vaginal wall appears first, and then the whole of the anterior vaginal wall from below upwards. This descent is brought about by intra-abdominal pressure separating the anterior vaginal wall from the posterior surface of the bladder. With the descent of the anterior vaginal wall the urethra and posterior wall of bladder also descend from the fact that the urethra is incorporated with the lower part of anterior vaginal wall. As the uterus is attached to the upper part of the vagina, it necessarily now descends, and in its descent it peels from above downwards the posterior vaginal wall from the anterior rectal wall. When the external os reaches the vulva, the posterior vaginal wall is bent upon itself, and as the uterus descends farther the whole of the posterior vaginal wall becomes everted, with the exception of that portion

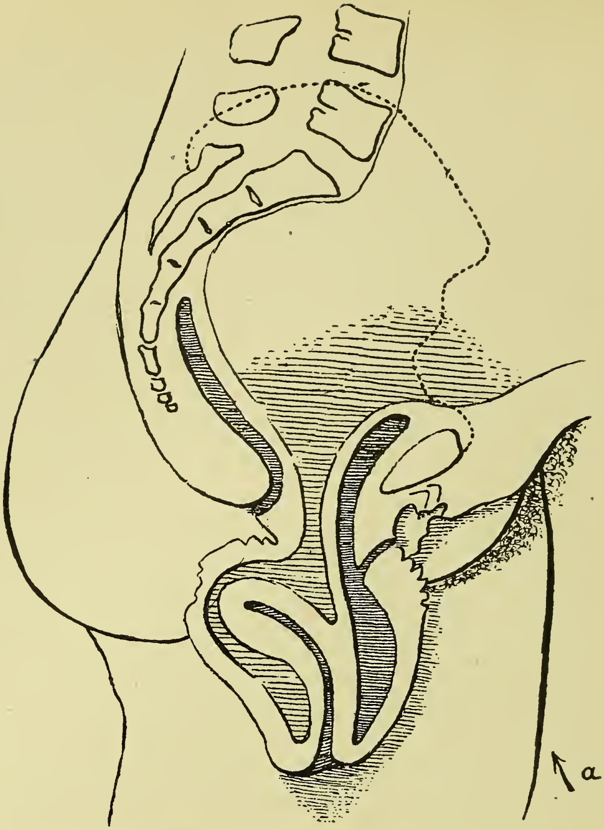

FIG. 2.—Position of the organs consequent on displacement of the pelvic floor.

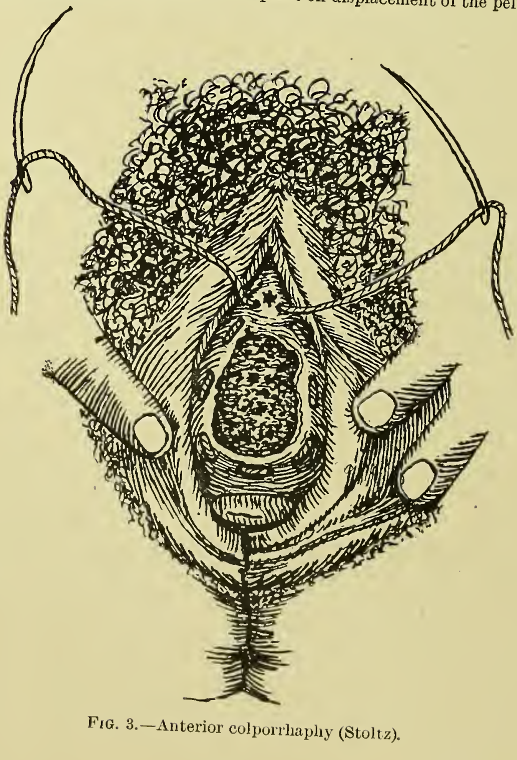

FIG. 3.—Anterior colporrhaphy (Stoltz).

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attached to the perineal body which is fixed to the rectum. So when prolapse is complete the whole uterus, the anterior vaginal wall, the urethra, part of the bladder, the posterior vaginal wall, and the peritoneum are all outside the vulva.

Thus the whole of the anterior segment accompanied by the uterus is outside the vulva.

Let us consider these different structures in their new situation (Fig. 2).

Urethra and Bladder.—The direction of the urethra is altered from downwards and forwards to upwards and forwards, and is completely extra pelvic. The base of bladder forming cystocele is outside the vulva, and is beneath the urethra, consequently one of the symptoms the patient complains of is dribbling away of urine.

The Anterior Vaginal Wall.—The whole extent of it is outside, and is subjected to irritation from exposure and friction. The result is that it becomes hypertrophied. The epithelium becomes thickened, resembles skin, the rugæ are undone, apt to get horny, or to ulcerate, often covered with a membrane. In long-standing cases changes take place in the bladder walls. They become hypertrophied and catarrhal, and not infrequently the catarrh extends to the ureters and pelvis of the kidney. In the prolapsed pouch of the bladder the urine becomes stagnant, and may lead to the formation of calculi.

The posterior vaginal wall assumes a similar condition to the anterior.

The Uterus.—The external os uteri is situated at the lower anterior part of the protrusion, the body of the uterus lies above it and posteriorly, and can be felt by the finger and thumb between the vaginal walls.

The external os uteri in some cases barely projects beyond the general surface of the protrusion, in other cases the cervix is greatly hypertrophied, and is frequently ulcerated. If it is lacerated the lips may be everted and eroded, and the mucosa of the cervical canal thickened and pouring out a copious secretion. While the body of the uterus will in many instances be found enlarged, with thickened walls and hypertrophied endometrium, in others, especially in women who have passed the menopause, it may be quite small.

The Peritoneum is driven down. The anterior and posterior uterine reflections are undone, so as to present when viewed from above a funnel-shaped opening, in the floor of which is seen the fundus, and at its sides and upper part, rather anteriorly, the ovaries and broad ligaments lie. The utero-sacral ligaments are much stretched, elongated, and thinned. The broad ligaments are also put on the stretch, and their attachments to the side wall of the pelvis are seen to be pulled on. The round are straightened out, but not stretched, unless the broad ligaments have given way.

The rectum remains in position, but the lower portion of it, which is attached to the perineal body, may be pulled forwards and a pouch formed. This constitutes "rectocele."

This process of descent is a gradual one, and it is convenient to divide it into three stages—

(1) The earliest stage, when the anterior vaginal wall with posterior wall of the bladder attached to it appears through the pudendal opening, constituting what is termed cystocele. The uterus in this instance has descended slightly, but is still anteverted.

(2) In descent of the second degree, the external os uteri is at the vulva and the uterus is retroverted. Cystocele and perhaps rectocele are also present.

(3) In descent of the third degree, bladder, both vaginal walls, uterus, and peritoneum are outside the vulva (Fig. 2).

Symptoms.—The patient complains of something coming down in front, or of the womb coming down. When she lies down and the examiner inspects the vulva he may find the parts apparently in a normal condition, inasmuch as no protrusion is to be seen, the explanation being that when the patient assumes the recumbent posture intra-abdominal pressure is removed, and the parts which were prolapsed when the patient was erect have sunk back into the pelvis. In such a case one has only to ask the recumbent patient to bear down, thus bringing intra-abdominal pressure into action, and the anterior vaginal wall will be seen to descend through the vulvar orifice in the shape of an egg. The patient also complains of a sense of weight and dragging in the back. When the uterus is enlarged and endometritis is present the menstrual flow may be profuse, but more often it is scanty. As a rule there is acquired sterility, but conception may take place in a prolapsed uterus and the pregnancy go to term. Abortion is apt to occur from incarceration when the enlarged uterus does not ascend above the pelvic brim. There are difficulties with micturition. In complete descent the direction of the long axis of the urethra is changed from downwards and forwards to upwards and forwards; a considerable portion of the bladder forms a pouch below the level of the urethra, consequently when the patient walks this pouch is subjected to pressure and the urine is forced out in jets *per urethram.* From the changed relations of bladder and urethra there is also difficulty in voiding urine, and some patients affirm that before they can accomplish the act they must push the protrusion back into the pelvis.

Differential diagnosis must be made from the following conditions:—

Hypertrophic elongation of the Vaginal portion of the Cervix.—In this condition the cervix is increased in length but not in thickness, the external os uteri, which is usually small, lies immediately within the vaginal orifice, while both anterior and posterior fornices are in their normal position, and the body of the uterus occupies its normal height in the pelvis. It is found in the virgin, and is probably congenital.

Hypertrophy of the Supravaginal portion of the Cervix.—The fundus uteri remains in its normal position, there is great increase in the length of the cervix, so that the external os comes to lie outside the vulva. Both anterior and posterior fornices are obliterated.

Inversion of the Uterus.—In this displacement a globular swelling occupies the vagina, at the upper end of which the uterus can be felt encircled by the cervix. On abdomino-rectal examination the body of the uterus is found to be absent from its normal position, and in its place the margin of a cup-shaped hollow may be palpated.

A uterine polypus which has become pediculated cannot be mistaken for prolapsus uteri if a careful examination be made. The finger introduced into the vagina can trace the pedicle of the tumour coming through the external os, and if a sound be passed the uterus will be found in its proper place.

Vaginal and vulvar tumours may simulate prolapsus uteri, but can always be differentiated. In the latter the external os can always be discerned at the apex of the protrusion. The only other condition in which this obtains is hypertrophic elongation of the cervix.

Cystocele and rectocele without accompanying prolapse of the uterus can be diagnosed by the passage of a sound into the bladder in cystocele, a finger into the rectum in rectocele, and by ascertaining bimanually that the uterus is in its normal position.

TREATMENT.—*Reduction.*—Reduction as a rule is accompanied with no difficulty. The structures can usually be replaced with ease when the patient assumes the recumbent position and the order of ascent is the reverse of the order of descent. The posterior vaginal wall is first reduced, then the uterus, and lastly the anterior vaginal wall and bladder. In old standing severe cases the prolapsed parts may be so congested and swollen that reduction cannot be effected without some preliminary treatment, taking the form of rest, hot applications, etc. The presence of intra-peritoneal adhesions may prevent reduction.

Retention.—Keeping in mind the factors which bring about this condition, our aim in treatment with a view to attaining permanent retention must be directed (1) to diminishing intra-abdominal pressure, and (2) to strengthening the pelvic floor so that it may successfully resist the pressure brought to bear on it.

(1) *Diminishing Intra-abdominal Pressure.*—This is best accomplished by rest. When a woman with a prolapsed uterus lies down the pressure is so diminished that the protrusion slides back or can be pushed back into the pelvis, and as long as she remains in this position there is little tendency for it to descend. Rest also enables the pelvic floor to regain its tone. Consequently a patient with this affection should rest as much as possible. Especially is it applicable in the puerperium in those who have any tendency to descent of the pelvic floor. But rest, however useful, is not sufficient to cure; even in the slightest and most favourable case we must adopt some plan of treatment whereby we strengthen the pelvic floor.

(2) *Strengthening the Pelvic Floor—Minor Measures.*—(*a*) Tampons. After the displacement has been reduced the vagina may be packed with cotton wool soaked in the following mixture—℞ Boroglyceride ℥ss., Aluminis ℥j., Glycerinum ad ℥xvj. The boroglyceride keeps the tampon from becoming fœtid, and along with the glycerine reduces the congestion of the parts, while the alum helps to tone up the relaxed structures. Tampons are serviceable in old women who are too feeble to undergo operative treatment, and in many cases are sufficient to keep up the protrusion. They require to be renewed at least once a week. Ichthyol may take the place of boroglyceride. Iodoform gauze or marine lint also makes an excellent pack.

(*b*) Pessaries are useful in cases in which the descent is slight and the perineum has not lost its retentive power, and in women who from age and general conditions are unsuitable for operation.

In cases of slight descent of the anterior vaginal wall the ring pessary, with perforated diaphragm, will be found most useful. The ring pessary strengthens the pelvic floor more than one after the Hodge pattern, while the diaphragm prevents the cystocele from slipping down. In most instances an efficient sacral segment is necessary for the retention of the instrument, but in exceptional cases one will find that this is not essential.

When the perineum is deficient and a pessary refuses to stay in, the addition of a perineal pad attached by strings to a waistband may secure its retention and make the patient comfortable. An instrument we have found very successful, even in cases of complete prolapse, is Simpson's disc and stem pessary. "The herniation," says Simpson, "can sometimes be prevented by making the patient wear a disc and stem pessary; the stem projecting from the lower surface of the disc lies between the labia. The disc may be circular, but is better elongated from side to side, so as to keep the walls of the vagina extended transversely. The patient learns easily to introduce such a pessary as she lies on her back, by passing in first the one side through the vaginal orifice and then the other, as a button is passed edgewise through a buttonhole. She removes it from time to time when going to bed by laying hold of the stem with the finger and thumb of one hand while the forefinger of the other hand lays hold of one edge of the disc and presses it out. She can thus secure the cleanliness of the instrument, and if need be she can douche the vaginal cavity in the interval of removal."

When the above mentioned pessaries fail, stem pessaries made of vulcanite or soft rubber with cup-shaped extremities attached by bands to a waistbelt, may be tried. For example Cutter's, or Leith-Napier's. We have found the latter's instrument the best of this class.

OPERATIVE MEASURES.—Before describing some of the numerous operations which have been devised for prolapse it will be well to mention those we consider suitable for cases met with respectively under the first, second, or third stage of descent respectively.

1st. *In the earliest stage*, when the lower end of the anterior vaginal wall appears at the vulva, the uterus being anteverted and the supporting segment intact, the operation indicated is anterior colporrhaphy, and after the patient has recovered from the operation it will be advisable as a precautionary measure that she wear a Hodge pessary for a considerable time to keep the uterus in anteversion.

2nd. *In cases of descent of the second degree*, where the uterus is retroverted and has descended so far that the external os uteri has reached the vulva, cystocele and perhaps rectocele being present and the perineum deficient. Here the operator will restore the integrity of the perineum, and will narrow the vagina by anterior and posterior colporrhaphy, or better by bilateral colporrhaphy. These operations do not affect the position of the uterus. It must be raised to its proper height, placed in anteversion, and measures taken to keep it in that position. To accomplish this we must adopt measures which will keep the cervix towards the sacrum (that is, which will perform the lost function of the utero-sacral ligaments) and the fundus to the front, so that intra-abdominal pressure may be directed on the posterior or upper surface of the uterus. The first of these indications may be fulfilled by the Hodge pessary, which, by pushing upwards and backwards the posterior fornix, keeps the cervix towards the back.

The pessary may be sufficient to keep the uterus in anteversion, but this result will be more certain of attainment if the operator in addition shortens the round ligaments extra-peritoneally. The maintenance of the uterus at its normal height in the pelvis, with its long axis directed towards the front, is all-important. If this cannot be accomplished, no matter how successful the operations which have been performed on the pelvic floor may be, a recurrence of the displacement is almost certain to occur sooner or later, for the simple reason that the uterus falls back into retroversion, and intra-abdominal pressure acting on the anterior surface of the uterus pushes down the pelvic floor. The operative measures alone mentioned we have found successful in many old and severe cases of prolapse. The pessary, which is playing the function of the utero-sacral ligaments, may, however, be rightly considered a weak point. In some cases of recent prolapse the utero-sacral ligaments may only be stretched and weakened, and may after a time regain their tone and function and allow the pessary to be dispensed with. But these are exceptions. In the majority of cases these ligaments are irreparably destroyed, and in them the pessary will be a necessity for an indefinite period. For these reasons some gynæcologists feel justified in opening the abdomen and adopting measures which will fix the uterus permanently in anteversion, and at a level which is either normal or above it. For accomplishing this end the gynæcologist may adopt the operation of ventral fixation devised by Olshausen and modified by Kelly, or he may attempt to attain the same end by restoring the utero-sacral ligaments, either by the recently introduced method of Stanmore Bishop or by that of Bowreman Jessett. These operations for the restoration of the utero-sacral ligaments fulfil the indications desired, and the operator can attain his object with greater certainty if he at the same time shortens the round ligaments intra-peritoneally.

3rd. *When the uterus is completely prolapsed* both vaginal walls are everted, and the bladder and peritoneum are outside the vulva. In extreme cases of this sort the surgical procedures mentioned under class 2 are applicable, especially in women who have not passed the menopause, or who, having passed it, are unwilling to have the marital function interfered with. Those not affected by this consideration may have an operation which has been recently introduced, and which promises to be a complete and permanent cure of the condition. The operation referred to consists in removal of the entire vagina and uterus, that is, panhystero-colpectomy.

In the foregoing summary we have mentioned various operations and their indications, and we now describe these operations in detail.

When the vaginal portion of the *cervix is hypertrophied* it should be amputated. This is done by fixing a volsella in the antero-posterior lip, and with a pair of strong scissors or a knife make a circular amputation, the edges being brought together by passing stitches antero-posteriorly, or better, from side to side, taking care not to obliterate the cervical canal.

Anterior Colporrhaphy.—One of the simplest methods is that of Stoltz (see Fig. 3), which consists in fixing the anterior vaginal wall at four points, and dissecting away all the redundant tissue between these, thereby making a raw surface which is narrowed by means of a suture introduced around the rawed surface in the form of a purse string. Another effective plan is to fix a volsella in the cervix and draw the latter down to the vulva, thereby making the anterior vaginal wall taut. With the knife one cuts through the entire thickness of the anterior vaginal wall in the middle line from cervix to pubes. The vaginal wall on each side of the incision is reflected off the bladder for a distance of about one inch, then the rawed surface of the vaginal wall on each side of the incision is brought into apposition by means of mattress sutures of thick catgut or silkworm gut, so that the reflected vaginal portions of the anterior vaginal wall resemble the keel of a ship.

A third method may be proceeded with in the following manner:—An elongated elliptical round surface is made on the anterior vaginal wall, beginning at the cervix and finishing near the urethral orifice. In the middle part the whole width of the vagina is rawed. The wound is brought together by a continuous catgut suture; the result is a great constriction of the lumen of the vagina. A similar procedure may be practised in the posterior vaginal wall.

Bilateral Colporrhaphy is one of the best methods of narrowing the vagina. In this operation a strip of mucous membrane is removed from the sides of the anterior and the posterior vaginal walls throughout the entire length of the vagina (Fig. 4), (fig. 594, p. 460, Montgomery's *Gynæcology*). The fixation of the parts is more permanent after this than after any of the operations already mentioned. It has the advantage that the narrowing can be made to any degree desired.

Restoration of the Perineum.—When the Tear does not extend into the Rectum.—The integrity of the perineum can be satisfactorily restored by a simple flap-splitting operation. The lower part of the posterior vaginal wall and the lateral margins of the vulva can be raised up in the form of a flap by simply carrying the knife or scissors underneath the parts mentioned and dissecting up the flap. A large rawed surface is produced which is brought together by a continuous catgut suture in such a manner that the whole of the rawed surface is brought into apposition, and the edges of the vulva meet in the middle line. The suture is introduced in the deepest part of the wound, and is carried upwards to the upper extremity of the wound, and then downwards alternately until the skin edge is reached. This method rolls the tissues up into the form of a thickened pad.

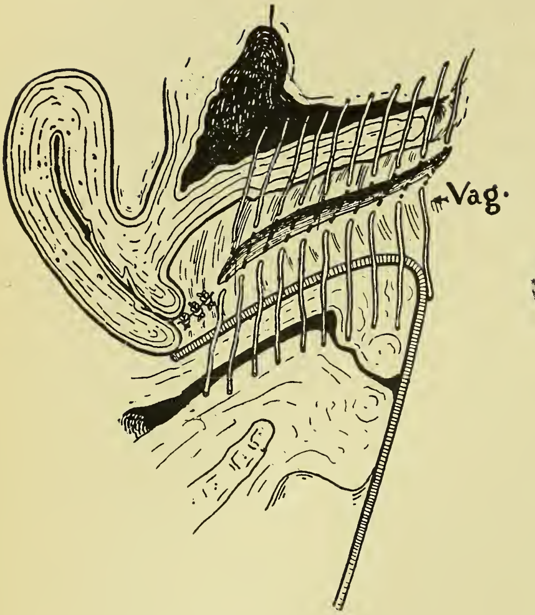

Fig. 4.—Bilateral colporrhaphy.

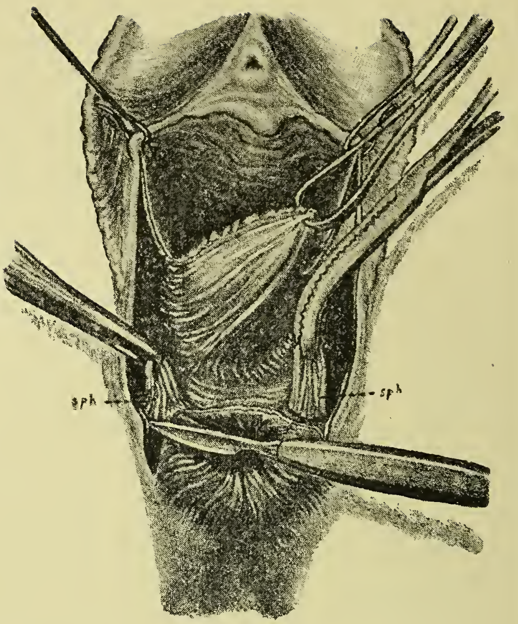

Fig. 5.—Restoration of the perineum when the rectum has been torn and the external sphincter muscle divided (Kelly.)

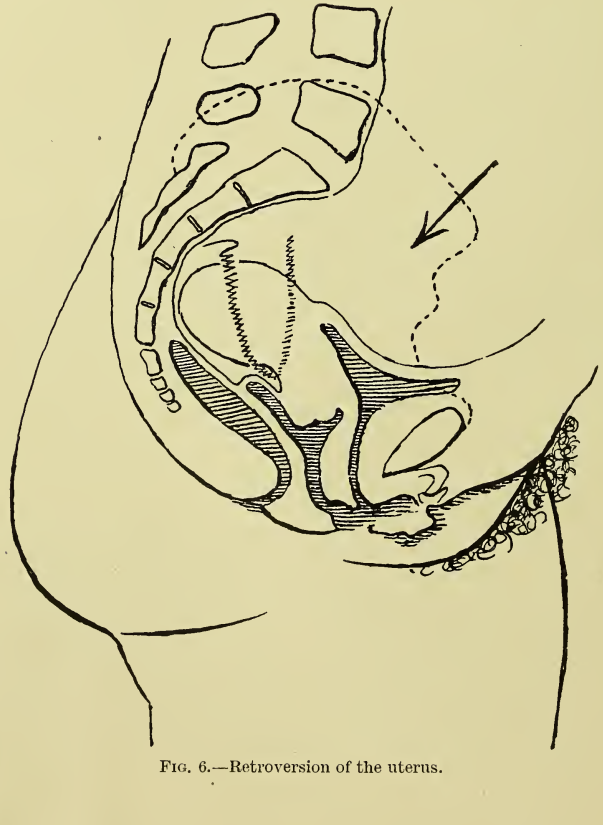

Fig. 6.—Retroversion of the uterus.

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When the Tear has extended into the Rectum and the External Sphincter Muscle is divided and retracted.—One of the best operations for the repair of this condition is one devised by Kelly, and is a flap-splitting method with the addition that the ends of the divided sphincter muscle are sought out, and by stitching are restored to normal shape and position (Fig. 5). The patient is placed in the lithotomy position, and after the field of operation has been thoroughly cleansed a plug of gauze is inserted into the rectum with a string attached to prevent the escape of fæcal matter during the operation. The assistants then stretch the recto-vaginal septum by placing a finger on the buttock immediately opposite each extremity of the septum. The operator then with the knife or scissors carefully separates the posterior vaginal wall from the anterior rectal wall to the extent of about one inch, taking care to avoid buttonholing. Then the knife or scissors is inserted at the extremity of the wound with which the operation was begun, and carried under the skin upwards along the margins of the vulva as far as the base of the nymphæ. Forceps are placed on the cut edges, and the flap is dissected upwards to the necessary extent. The operator then carries two incisions downward and backwards directly over the retracted ends of the sphincter, which can always be felt between the finger and thumb, and there is seen always a slight dimple on the skin at the retracted end. The ends of the sphincter are now carefully dissected out, and seized with forceps which pull them into their original position and hold them there while the operator stitches them together with catgut. It is usual to put in three stitches. It is advisable to insert at this stage a silk-worm gut suture from the cut edge of the skin on one side through the restored sphincter, to be brought out at the edge on the opposite side with the object of supporting the parts. This suture may be cut short and may remain as a permanent buried suture. The further stages of the operation consist in bringing all the rawed surfaces together. This again is best accomplished by the continuous suture of catgut in the same way as described in the previous operation.

Ventral Fixation.—In order that this operation may be of any service in the treatment of prolapse, the uterus must be firmly fixed in the abdominal parietes. The uterus is drawn up into the abdominal wound, two stitches are inserted through it to the depth of about ¼ inch on its posterior aspect, immediately below the fundus, with the object of keeping it in anteversion, so that intra-abdominal pressure may be exerted on the posterior or upper surface of the organ. The material may be either silk, silkworm gut, or chromicised catgut. Many operators will doubtless prefer a non-absorbable material where such a firm fixation is required. The operation should be limited to those cases in which pregnancy is impossible.

Intra-peritoneal Shortening of the Round Ligaments.—This operation consists in doubling up from two to four inches of the round ligament on each side and uniting it by sutures. The shortening thus produced keeps the fundus uteri towards the front. It will be well in this operation to use a non-absorbable suture.

Operations for the restoration of the utero-sacral ligaments may be accomplished —(*a*) By the method of Jessett. He describes the operation thus : "In cases of complete procidentia, in which the peritoneum in Douglas's pouch is prolonged quite through the vulva, the sacro-uterine ligaments, which have become much elongated, should be restored by drawing up the posterior fornix of the vagina, and fixing the peritoneum covering it to the posterior wall of the uterus and to the parietal peritoneum lining the sacrum. If necessary a fold or tuck may be made in each broad ligament, and in cases of cystocele the bladder may be drawn up and stitched to the peritoneum covering the uterus" (*British Gynæcological Journal*, May 1901, pp. 29, 30).

(*b*) Another method is that of Bishop. He says : "The technique of the operation, as I have carried it out, is briefly this. The protrusion being reduced the patient is placed in the extreme Trendelenburg position, and the abdominal wall is opened by a median incision. As soon as the intestines have sunk away from the pelvis towards the diaphragm, two threads are passed through the broad ligaments, one on either side of the uterus, enclosing tube and round ligament ; the ends of these threads are tied, and by them as tractors the fundus of the uterus is drawn forwards. A special sound is passed by an assistant into the vagina, and made to press up towards the posterior fornix so as to render it prominent. On either side a stout, thick thread is passed vertically through the substance of the fornix, avoiding the mucous lining, so that each protruding end is half an inch distant from the other, and the whole loop half to three-quarters of an inch from the cervix. The fornix is now applied to the sacrum, and a spot is chosen directly opposite, free from vessels and subjacent nerves and ureter, and well outside the rectum, where the needle carrying this suture is entered deeply so as to embrace the periosteum covering the bone; it is brought out again half an inch directly above its point of entrance. Before tying this suture a narrow strip of peritoneum is removed from that portion of the fornix which lies in its grip, so as to bare the connective tissue beneath. This is repeated on the opposite side; the sutures are tied, and their ends cut short. Sometimes the position of the rectum will only permit of single fixation. This should then be more central in its position as regards the uterus, and somewhat broader. The new ligament or ligaments are now formed, and the cervix hangs in its normal position from the sacrum by that portion of the vagina which lies between it and the sutures" (*Medical Press*, 24th December 1902).

(*c*) *Panhystero-colpectomy.*—This operation has been performed by several operators with good results. The method described by C. Martin of Birmingham is excellent, and we here give his description of it:—

"(1) The patient was anæsthetised and placed in the lithotomy position, and the vulva, cervix, and vagina (which was completely turned inside out) rendered aseptic.

"(2) The cervix was seized with volsella and drawn forward, and an incision made through the vaginal mucous membrane from the posterior lip of the cervix to the edge of the perineum. From the latter point two curved incisions were carried forward, one on either side at the junction of the vaginal mucous membrane and the skin of the labia, meeting in front about three-quarters of an inch behind the meatus urinarius, that is, near the posterior edge of the vestibule. It will be seen that these incisions encircled the ostium vaginæ.

"(3) The mucous membrane of the posterior vaginal wall was dissected off with scissors and turned forward; but at this stage the mucous membrane of the anterior vaginal wall was not interfered with.

"(4) The peritoneum of the pouch of Douglas was next opened by a transverse incision, and the uterine fundus exposed and drawn down. The broad ligaments were ligatured and divided from above downwards outside the ovaries and tubes.

"(5) The peritoneum between the bladder and uterus was divided transversely, and the bladder stripped off the cervix and upper part of the vaginal wall with the finger.

"(6) The mucous membrane of the anterior vaginal wall was next dissected off the bladder with scissors, and the uterus, ovaries, and tubes, together with the whole vaginal mucous membrane, removed in one piece.

"(7) All bleeding points having been seized and ligatured with fine silk, the peritoneum of the pouch of Douglas was sutured to that on the bladder with a fine silk suture.

"(8) The fascia at one side of the vagina was next sutured to that on the other side by a fine continuous suture beginning above at the level of the broad ligaments, and working gradually downwards to just above the vulva. In this way the bladder was pushed forward and the rectum backward by a firm column of connective tissue derived from the lateral fasciæ.

"(9) The vulvar wound was then closed by interrupted silkworm gut sutures approximating the posterior halves of the labia majora.

"(10) The wound was dusted with iodoform, and a pad of iodoform applied. For some days the patient's urine was drawn off through a catheter. She was kept in bed for three weeks. After leaving the hospital she continued to improve, and when I saw her again on 30th June (the operation was performed on 11th May), she was quite well. Since that date she has been to the out-patient department to report herself from time to time. I examined her in the early part of July, and found her condition most satisfactory. She was perfectly comfortable, had complete control of the bladder, and no trace of any protrusion of any kind. The vulvar scar was quite painless, and, in her own words, 'life was now a pleasure instead of a continual misery'" (*British Medical Journal*, 5th October 1901).

4. ANTEPOSITION—RETROPOSITION—DEXTRO-POSITION—SINISTRO-POSITION. — In this group of displacements the uterus has been moved bodily from the normal position like one of the above-mentioned. These abnormal positions are caused either by tumours pushing the organ out of its place, or by cicatricial contractions drawing it out of place. Tumours of the sacrum, rectum, and ovaries, tumour in Douglas's pouch, or a fibroid tumour growing from the posterior wall of the uterus, may push the organ forwards into anteposition. The same result may be caused

by hæmorrhagic extravasation or inflammatory effusion in Douglas's pouch. The organ may also be drawn forward by the cicatricial contractions resulting from anterior parametritis.

5. Retroposition.—Tumours in front of the uterus push it into retroposition, such as tumours of the bladder or ovarian tumours. The influences which produce this position, acting from behind, are the adhesions which result from either a collection of serous matter or extravasation of blood.

6. Sinistro- and Dextro-position of the uterus are produced by tumours growing between the layers of the broad ligament, or are the results of cicatrisation following the inflammation of the connective tissue of these layers.

It is noteworthy that an inflammatory or a hæmorrhagic swelling, which at an early stage produces one displacement, at a later period produces a displacement in the opposite direction. For example, a swelling of that nature in Douglas's pouch during the earlier stages of its existence thrusts the uterus forwards into anteposition, while at a later stage, after absorption has been well accomplished, cicatrisation follows and pulls the uterus back into retroposition. In like manner a cellulitis between the layers of the left broad ligament pushes the uterus to the right side of the pelvis, while after absorption and the cicatricial contraction which follows it have occurred, the uterus is drawn to the left side of the pelvic cavity. The left lateral position of the uterus is a very common displacement, and is explained by the frequent occurrence of left-sided cellulitis arising from the frequency of a tear on the left side of the cervix during labour, and the septic absorption which follows it.

Retroposition of the uterus frequently gives rise to troublesome rectal symptoms from stenosis, owing to the narrowing of the rectum, which is inevitable at the site of the peritonitic bands and consequent interference of its function. The diagnosis of all these positions is very important, more especially in ante- and retroposition. It may be difficult to differentiate the uterine body from the swelling which produces the displacement. The careful use of the sound and bimanual examination under an anæsthetic should clear up the matter in case of doubt The practitioner cannot exercise too much care in recognising the presence of retro-peritoneal hæmatocele. This condition has frequently been mistaken. for an enlarged retroverted uterus, and attempts at replacing such have been followed by most disastrous results. All the above displacements do not call for treatment, but the condition causing them does so.

7. Pathological Anteversion and Anteflexion.—The uterus normally is anteverted and anteflexed, but the degree of version and flexion which may be considered physiological cannot be defined, and what one examiner may consider pathological another would consider normal. Symptoms do not help us much in making the definition, because one patient may have an exaggerated anteversion, without symptoms, or the change in the inclination and the bend of the uterus may be very slight, yet the symptoms may be well marked. And again, the symptoms may be due, not to the displacement, but to the causes which produce it. There are, however, two well-defined anomalies of the normal condition which can be without doubt pronounced pathological. These are known as pathological anteflexion and pathological anteversion, both of which occur as the result of inflammation posterior to the uterus, and the chief characteristic of these forward displacements is that the uterus has lost its normal mobility. Schultze defines pathological anteversion as "that position of the uterus in which, extended in shape, it lies with the fundus forwards, and is more than normally stabile," and pathological anteflexion as "that position of the uterus in which, permanently flexed over its anterior surface, it lies with the fundus forwards, and is more than normally stabile."

Pathological Anteversion.—*Physical Signs.*—The uterus is straightened out, the relation between the body and cervix is altered, that is, the normal anteflexion is abolished. The body is enlarged, is stiff and rigid, and has lost its flexibility and much of its mobility.

On making a bimanual examination, the vaginal portion of the cervix will be felt high placed and altered in direction from downwards and backwards to backwards and upwards. Through the anterior fornix the enlarged body of the uterus will be made out, hard in consistence, with its mobility impaired, while the body and cervix will be felt to be in the same straight line. If a thorough examination be made under anæsthesia inflammatory thickening may be recognised in the region of the utero-sacral ligaments. This thickening can be best felt *per rectum.*

Ætiology.—Anteversion is generally a result of puerperal inflammation. The extended shape of the uterus is due to metritis, which is usually brought about by interference with the involution of the uterus. The metritis makes the uterus rigid, and increases its bulk. Posterior cellulitis accompanies the metritis, and leads to rigidity and contraction of the utero-sacral ligaments, which pull up and fix the cervix to the sacrum at a high level. Intra-abdominal pressure pushes down the rigid, straightened out body, while the cervix is moved in an elevated position posteriorly.

Symptoms.—The symptoms are those of metritis and posterior cellulitis. In addition there may be added vesical troubles, pain whenever the bladder becomes moderately distended, and frequent desire to micturate.

Pathological Anteflexion.—*Physical Signs.*—On bimanual examination the vaginal portion of the cervix will be found high placed and nearer the sacrum than normal. Through the anterior fornix the body of the uterus is felt acutely flexed on the cervix. The uterus may be flexible, or it may have lost its flexibility. The thickened utero-sacral ligaments may be palpated through the posterior fornix, and the examiner will feel that they prevent him from drawing the uterus forward to the front.

Ætiology.—The commonest cause of pathological anteflexion is shortening of the utero-sacral ligaments, the result of cellulitis. The contracted folds of Douglas pull the cervix back towards the sacrum, and fix it there. Intra-abdominal pressure acting on the posterior surface of the uterus, which is still flexible, pushes it downwards towards the anterior aspect of the cervix, thus producing an exaggerated anteflexion. The subsequent metritis destroys its flexibility. The posterior cellulitis is not always puerperal, as it is frequently met with in the unmarried and in those who have had no children.

Symptoms.—The symptoms are those of utero-sacral cellulitis, metritis, and endometritis. Pain in the back, and pain and difficulty in defæcation, are the leading symptoms which can be attributed to the posterior inflammation. The uterine conditions give rise to leucorrhœa, perhaps menorrhagia, dysmenorrhœa, and sterility.

Treatment.—Treatment is directed to the abnormal condition of the utero-sacral ligaments and of the uterus. Pain in the back, which is due to dragging of the uterus on the shortened and inflamed ligaments, should be treated in such a way as to procure rest to these structures. The chief factors producing unrest or tension of these are—(1) passage of large masses of fæces; (2) intra-abdominal pressure forcing down the uterus. The first of these is treated by aperients or by daily enemata. Intra-abdominal pressure is minimised by rest, and is resisted by a Hodge or figure-of-eight pessary, which by its upward pressure supports the uterus, and thus removes the tension from the utero-sacral ligaments, and relieves the dragging pain in the back which is the leading symptom of this condition. One may also attempt to restore the ligaments to their normal condition by first promoting absorption of the thickening. This may be accomplished by glycerine plugs, hot douches, warm sitz baths, or special treatment at watering-places such as Kissingen, Marienbad, where the methodical application of heat is practised in the form of sulphur, peat, or sand baths. Secondly, by endeavouring to lengthen the ligaments by massage under anæsthesia, or as has been recently advocated by Reed of Chicago, one may cut through the posterior vaginal wall and resect the ligaments, thus allowing the cervix to come forward and assume a more normal position. The dysmenorrhœa may be premenstrual and menstrual. In the former case it may be attributed to the congestion which takes place in the pelvis before the flow appears, and which would affect the inflamed ligaments. The pain which is present during the period is due to the metritis, endometritis, and the acute bend between the body and cervix. Dilating the uterus and curetting the endometrium will be found most beneficial. Should any erosions be present on the vaginal portion, or if the cervix is lacerated or hypertrophied, these conditions should receive appropriate treatment.

8. Congenital Anteflexion.—Under this term is usually described a uterus having the characters of that of the child. In early life the body of the uterus is small, and acutely anteflexed on a comparatively large cervix. At puberty the body should enlarge and become more erect, but when it fails to do so the organ retains its childish shape. This anomalous form of uterus being due, therefore, to an arrest in the development of the organ, cannot be properly considered a displacement, though it is generally classed amongst them.

Physical Signs.—In a typical case they are as follows:—The vagina is short, the cervix, which lies in the long axis of the vagina, is long, slender, and pointed.

The increased length of the intermediate portion is usually very marked. The external os uteri is small and round (pinhole os), the body of the uterus is also small and round, and is acutely anteflexed on the cervix. The flexibility is increased in some cases, and in some cases the corpus uteri is not deficient in size.

Associated with this condition there is occasionally thickening and shortening of the utero-sacral ligaments.

Symptoms.—The chief are dysmenorrhœa and sterility. The onset of pain usually occurs a day or two before the period, and continues severe during the first day or until the flow is established. The amount of menstrual discharge is scanty, usually pale in colour, frequently clotted, and sometimes contains pieces of membrane. Occasionally the menstrual flow is copious. Sometimes there is frequency of micturition. Specially is this the case during the periods. In severe cases the premenstrual pain may last a week, and in some there may be more or less continuous intermenstrual pain. Frequently there is dyspareunia.

Treatment.—In the unmarried, dysmenorrhœa is the most urgent symptom. In the married, sterility is often quite as important. Both symptoms may be said to be due in the majority of cases to the shape of the uterus. The obstacle to the easy outflow of menstrual fluid is the narrowness of both the external and the internal os uteri, and explains in the most rational manner the production of the dysmenorrhœa. It is also not unreasonable to consider the sterility due to the same obstruction. The relief which the patient obtains from pain, as well as the frequency with which sterility is cured by free division of the cervix and dilatation of the internal os, justify the above view. The pain is sometimes in part due to the accompanying endometritis and utero-sacral cellulitis, and in instances where this symptom is in force throughout the intermenstrual period the operator may infer that the uterine adnexa, particularly the tubes, are at fault. In a few cases of this class, in which the symptoms were severe, we found on abdominal section that the tubes were imperfectly developed with blind extremities. In extreme cases abdominal section is justifiable for the purpose of removal of the tubes and ovaries to induce the menopause, but even in such cases one would first try the effect of division of the cervix and dilatation of the internal os. The best operation for accomplishing the latter object is that of Dudley of Chicago, in which not only is the external os permanently enlarged and the internal os dilated, but the flexure is overcome by altering the direction of the cervix from downwards to downwards and backwards. The operation also removes any endometritis that may be present.

The patient is put in the lithotomy position, the speculum is introduced, the cervix is divided with scissors backward in the middle line past the utero-vaginal attachment. The uterus is then dilated and curetted. For the rest of the operation we quote Dudley's own words : "The cut surfaces thus incised are then held widely apart by means of two tenacula in the hands of an assistant ; the incision is somewhat deepened by means of a scalpel, especially in the uterine wall next to the cervical canal, and a small angle is cut out on either side, as shown by the dotted line in Fig. 382. The cut surface on each side is now folded on itself by a single silkworm gut suture, as shown in Fig. 382. This suture is tied and fortified by interrupted sutures on either side. The lines of union thus made are shown in Fig. 383. These sutures are not introduced in such a manner as to stitch the intracervical to the vaginal margin of the wound, but the cut surface is folded upon itself in a direction at right angles to this. On either side, that point at the margin of the os externum where the backward incision commenced is stitched to the very angle of the incision, so that each cut surface is folded upon itself, not from within outward, but from before backward. Thereby the os externum is carried directly back to the angle of the incision. The cervix now points backward in its normal direction toward the hollow of the sacrum, instead of forward toward the vaginal outlet. . . . Conjoined examination upon completion of the operation in each of the author's cases has invariably shown the uterus either to have been straightened, or the anteflexion to have been reduced to a degree quite within physiological limits. The results have been substantially the same whether the point of flexure was at the os internum or below it. The two posterior lines of sutures have the effect of transplanting the os externum to the very angle of the posterior incision. The anterior sutures, if used, have the effect of carrying the cervix back by a distance equal to one-half the length of the anterior cut surface, which is doubled upon itself. By these means a permanent change, quite equal to overcoming the flexure, is effected in the direction of the cervix. As the result of the anterior portion of the operation, the uterus in a suitable case is lifted also to a higher plane in the pelvis, where it ceases to be a mechanical irritant to the bladder. This portion of the operation may therefore be indicated for descent when complicated with anteflexion" (Dudley, *Diseases of Women*, p. 581, etc.).

From a large experience of this operation we are well satisfied with the results. As a rule, patients are cured of the dysmenorrhœa for a considerable length of time, and very frequently pregnancy occurs after the operation. The introduction of a glass stem pessary half an inch in diameter after the posterior lip of the cervix has been divided and the internal os widely stretched is a method favoured by some operators. The stem pessary is kept in position by packing the upper part of the vagina with iodoform gauze, and may be kept in the uterus five or six days. After the instrument is removed the cavity of the uterus should be irrigated with an antiseptic solution. The results of this method are not likely to be so lasting as after Dudley's operation.

Treatment short of operative measures consists in giving remedies with a view to the alleviation of symptoms. Counter-irritation in the form of small fly blisters applied over the seat of pain whenever it commences is one of the most effective remedies for dysmenorrhœa. The promotion of diaphoresis at the outset is helpful. No anodyne, with the exception of morphia, is likely to remove the pain, and morphia cannot be too strictly forbidden, as the symptoms of anteflexion lend themselves to the acquirement of the morphia habit.

9. Retroversion and Retroflexion.—These retro-deviations are of frequent occurrence. In some instances they give rise to no appreciable symptoms, in others the symptoms they cause are very persistent and troublesome.

Retroversion occurs when the uterus rotates round an imaginary transverse axis—the fundus backwards, the cervix forwards. This displacement occurs physiologically whenever the bladder is fully distended, but this is a temporary displacement. Whenever it becomes permanent it is pathological. It occurs as a congenital condition associated with a shortening of the anterior vaginal wall. It is also the position the uterus assumes in senile involution. When a retroverted uterus is abnormally rigid, as when stiffened by metritis, it remains extended, but when it is not rigid intra-abdominal pressure directed against its anterior surface causes it to bend at the isthmus, and the body is bent over on the posterior surface, thus producing retroflexion.

Etiology.—The commonest factor in the production of *retro-displacements* is a relaxed condition of the utero-sacral ligaments. This relaxation may be produced by habitual over-distension of the rectum in a debilitated subject, but the most frequent cause of the condition is the puerperal state. In the puerperium the uterus is large, soft, and heavy, and all its ligaments are lax. While in this state an over-distended bladder may easily push the uterus into retroversion, more especially if it is aided by the intra-abdominal pressure which would accompany any muscular effort on the part of the mother such as lifting the child. The return of the uterus into anteversion, which should follow the emptying of the bladder, does not take place owing to the toneless condition of the round and utero-sacral ligaments. The consequence is that the latter are stretched and lengthened, and intra-abdominal pressure now acting on the anterior surface of the uterus, the latter remains permanently in retroversion (Fig. 6).

The displacement may be produced in the non-puerperal state in a somewhat similar manner when there is an increase of intra-abdominal pressure, as in vomiting, lifting heavy weights, or overreaching. This can only occur when the bladder is full. It may also take place without distension of the bladder, as when a patient receives a fall on her sacrum.

Inflammatory action behind, or in the cellular tissue in front of, the uterus, may draw it out of its place and fix it in retroversion; while tumours in front may push it into the abdominal position.

Physical Signs.—The vaginal portion of the cervix is low placed and directed downwards, or downwards and forwards. The vaginal walls are lax. Through the posterior fornix a body is felt, which on bimanual examination is found to be the corpus uteri. The fundus is directed towards the sacrum, the degree of retroversion being determined by the particular portion of the sacrum opposite which it is found. With the exception of congenital and senile cases the uterus is usually enlarged in a uniform manner and of soft consistence. In most instances the mobility of the organ can be made out by the examining finger, though in some the assistance of anæsthesia will be required. In retroversion the rigid body is extended, and in the same straight line with the cervix; while in retroflexion an angle is felt on the posterior aspect of the uterus, generally at the junction of body and cervix.

Symptoms.—Menorrhagia and leucorrhœa are marked symptoms, and are due to the accompanying metritis. When menorrhagia occurs during lactation the uterus will generally be found retroverted. Bearing down is frequently complained of, and may be attributed to the low position and increased size of the uterus. Pain in the back is a prominent symptom, and is due to the stretching of nerve filaments chiefly in the elongated utero-sacral ligaments. Difficulty and pain in micturition and defæcation are also common symptoms. Conception may occur, and in many instances the pregnancy reaches full term. Incarceration sometimes takes place about the fourth month. Women who always abort may carry to term after the uterus has been replaced.

Treatment.—The metritis and other associated inflammatory conditions must first be treated. Rest, tampons, the hot douche, and curettage will be found most serviceable for this purpose. After all tenderness has been removed the displaced organ must be replaced. This is accomplished best of all by bimanual reposition, usually with the patient anæsthetised, or the uterus may be brought to the front with the sound, or by making the patient assume the genupectoral position and pushing the uterus forwards by a finger in the rectum. The retention of the uterus in anteversion is effected by vaginal pessaries or by various operative procedures. The Hodge pessary, or some modification of it, is best suited for the purpose. A pessary acts by keeping the cervix towards the sacrum, and thus fulfilling the function of the utero-sacral ligaments. Many operations have been devised to retain the fundus permanently to the front. We will mention four of the more prominent. *Vaginal fixation*, by which the anterior surface of the corpus uteri is fixed in an incision made in the anterior vaginal wall, while it accomplishes its object, cannot be regarded with favour owing to the risk in subsequent pregnancy and labour, but in women past the child-bearing period it is quite a good method. *Ventral fixation* consists in fixing the body or fundus to the anterior abdominal wall. The risks to pregnancy are the same as those of vaginal fixation, though in a minor degree; and the operation of necessity involves the opening of the peritoneal cavity. *Shortening the round ligaments* by the Alexander-Adams method keeps the uterus in anteversion, but does not fix it, and therefore the fundus is not prevented from ascending during pregnancy. It is performed extraperitoneally, and is attended by practically no risks. *Shortening the utero-sacral* ligaments through the vagina, as recently planned by Bovèe, promises well. Its aim, the restoration of the function of the utero-sacral ligaments, is correct in principle. If this can be attained the operation should, together with that of shortening the round ligaments, restore the normal position of a movable retroverted or retroflexed uterus.

Fixed retroversion or retroflexion requires for its treatment the removal of the cause which produces it before replacement and retention are attempted.

III. Inflammations of the Uterus

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ACUTE *Metritis and Endometritis.*—Acute inflammation of the uterus, when compared with the chronic form, is a comparatively rare disease. And while the latter is often confined to one layer of the uterine wall, in acute inflammation we generally find the peritoneum, the muscular tissue, and mucous lining all equally involved at the same time.

Etiology.—It is most frequently met with as a result of septic infection following childbirth or abortion, the infection taking place at the placental site or from some laceration of the cervix. Septic infection may also result from the use of the uterine sound, tents, or intra-uterine pessaries, or follow operations on the uterus, such as the removal of a polypus or curetting of the endometrium. After septic infection extension of a gonorrhœal inflammation from the vulva and vagina ranks second in importance as a cause of acute uterine inflammation. An acute general inflammation of the uterus, which probably starts from the endometrium, is occasionally met with during the progress of the exanthematous fevers, *e.g.* scarlatina and typhoid. Sudden suppression of the menstrual flow from chill or excitement is said to cause it, but this is doubtful. Formerly, when strong caustics were so much in vogue in treatment of uterine disease, acute inflammation not infrequently followed their use.

Symptoms.—The disease is generally ushered in by a rigor followed by fever. The temperature may range from 102°-105°, and there may be several chills in the course of the twenty-four hours. The pulse is rapid, 110-120. Locally, there is more or less acute pain in the pelvis, with great tenderness on palpation over the fundus uteri. There may be great rectal and vesical tenesmus. In septic puerperal cases the lochial discharge is generally fœtid and greatly diminished in quantity. In non-puerperal cases the uterine discharge is at first serous and then muco-purulent. In rare instances it may be sanguinolent from the commencement.

Physical Signs.—Vaginal examination reveals a hot, moist vagina, the cervix swollen, the os patulous, and the uterus enlarged, softened, and very tender. These signs, taken in conjunction with the acute character of the symptoms and the history of the case, leave no doubt as to the diagnosis.

The prognosis in puerperal cases is of course very grave. The same is true in cases following gonorrhœa and operative interference, though here there is not the same tendency for the inflammation to become general or for a general infection to occur.

Prophylaxis.—The causes of acute inflammation which have been given indicate how the disease in the great majority of cases may be prevented, viz. by the careful use of antiseptics during labour and in all gynecological operations and manipulations. During menstruation women should avoid exposure to cold and too great physical exertion.

Treatment.—The treatment of acute septic inflammation of the uterus is considered under the head of "PUERPERAL FEVER," and need not therefore be referred to here, for whether puerperal or non-puerperal the disease is to be combated by the same measures, though, as we have stated, with a greater hope of success in the non-puerperal cases.

In the less acute form of acute inflammation, non-septic in origin, the patient must be kept absolutely at rest. Hot fomentations or an ice-bag where the temperature is very high, over the lower abdomen, give great relief to the pain. Hot vaginal douches act in the same way, and tend to relieve the congestion and allay the inflammation. If the pain is very severe morphia may be necessary, when it is best administered in the form of a suppository. To avoid any straining the bowels should be moved by an enema each morning, and for the same reason the catheter should be passed to draw off the urine.

Stimulants as a rule are not indicated or necessary in the non-septic cases. The acute symptoms as a rule pass off within ten days, but there is a great liability for the disease to remain for a long time in a chronic form, so that our prognosis as to complete recovery should always be guarded.

Chronic Metritis.—Chronic metritis is a term applied to a morbid condition of the uterus, which has been described by different authors under various terms, viz. chronic parenchymatous inflammation (Scanzoni); areolar hyperplasia (Thomas); irritable uterus (Hodge and Gooch); diffuse interstitial metritis (Noeggerath); subinvolution (Sir J. Y. Simpson);

hyperplasia of the fibro-muscular tissue of the uterus (Virchow), etc. Clinically, it is applied to a uterus which is "enlarged, painful, and tender" (Herman), and is one of the most common, if not *the* most common, diseases of the female sexual organs.

The essential pathological change in chronic metritis is a great increase in the connective tissue elements, not localised as in fibrous tumours, but diffused through the whole organ. This may be the result of a previous acute inflammation, but only very rarely is this so. In the great majority of cases it is the result only of long-standing congestion, and is thus analogous to the fibroid changes produced in other organs under similar conditions, *e.g.* cirrhosis of the liver.

Subinvolution of the uterus and chronic metritis are by some authorities considered to be the same pathological condition, but while subinvolution is undoubtedly a very frequent cause, and in many cases the starting-point of the irritable, painful uterus which we designate under the term chronic metritis, the two morbid conditions are, we believe, quite distinct.

Subinvolution may be present to a very considerable degree, and cause no symptoms except an increase in the amount of the menstrual discharge.

Chronic metritis is always associated with much pelvic pain, dysmenorrhœa, and generally by ill health, in addition to menorrhagia. It may also occur in women who have never borne children.

Etiology.—Chronic metritis may sometimes, as has been stated, be but the chronic stage or result of an antecedent acute inflammation of the fibrous tissue of the uterus. In but a very small proportion of the cases, however, where the disease is present will we be able to get a history of any acute symptoms occurring much more frequently in parous than in nulliparous women; we will find very often that its onset is in some way associated with a previous labour or abortion; when we may conclude it had its starting-point in an imperfect involution of the uterus, or was due to some chronic infective process, the real nature of which we still imperfectly understand.

This absence of any acute stage is very characteristic of inflammation generally in connection with the female sexual organs. In the great majority of cases of endometritis, endocervicitis, ovaritis, and salpingitis, the inflammation runs a subacute course from the commencement. The same thing is true of pelvic cellulitis and peritonitis.

Displacements of the Uterus; Retroflexion and Congenital Anteflexion.—The presence of tumours in or near the uterus; stenosis of cervix; laceration of the cervix and cervical catarrh; endometritis, and the repeated application of caustics to the endometrium; exposure to cold during menstruation; improper clothing; excessive sexual intercourse; irritation produced by a badly-fitting vaginal pessary, or from an intra-uterine stem pessary, are all causes of chronic metritis, which probably acts by producing long-standing or repeated congestion of the uterine blood-vessels.

Symptoms.—The prominent symptom is pelvic pain, dull, aching, or bearing down in its character, referred to the lower abdomen or sacral regions. This pain, though more or less constantly present, is always worse on excitation, and is greatly aggravated immediately before and during menstruation. Along with this pain in the pelvis are associated other local symptoms, such as menorrhagia, leucorrhœa, and dysmenorrhœa. Painful defæcation and micturition are frequently complained of, and dyspareunia is always present. The patient is generally sterile, or if she becomes pregnant, aborts in the early months. As a result of the prolonged suffering and enforced sedentary habits, the subjects of chronic metritis frequently pass into a state of semi-invalidism, or become markedly neurasthenic. Chronic metritis is said to be responsible for a large proportion of the sofa and bath-chair population—the nervous, debilitated, dyspeptic women who wander from physician to physician or crowd the watering-places during the summer. No disease is more chronic, none is more difficult to treat successfully. In many cases relief is got at the menopause. Too much reliance should not be placed on this, however. The pelvic pain may continue for years after, while the nervous symptoms very frequently become more marked at the climacteric.

Treatment.—Treatment after childbirth and abortion, which is directed towards securing a perfect involution of the uterus, is the best preventive treatment of chronic metritis, the chronic congestion of the subinvoluted uterus being perhaps the commonest factor in the production of chronic metritis.

The treatment when the disease is already present is very unsatisfactory and its results very uncertain, and in carrying it out great patience is necessary both on the part of the physician and the patient. In long-standing cases months may be necessary to effect even an approximate cure.

From what has been said as to the pathology, probable cause, and symptoms of chronic metritis, it will be seen that the treatment must be both local and constitutional. The chief aim of local treatment is to diminish or prevent the uterine congestion which, if we cannot say definitely is the cause, at any rate we know greatly aggravates the condition. This passive congestion is best relieved by the use of the hot vaginal douche and the glycerine tampon.

There are few cases of chronic metritis which will not benefit very markedly by a six weeks' or two months' course of douching and plugging if the treatment is properly carried out. Where possible it should be done by a trained nurse. For the first week the douche only should be used three or four times daily. The time occupied on each occasion should be not less than ten minutes, and the douche nozzle should be introduced well up to the roof of the vagina. The amount of fluid used is of no importance so long as the parts are fomented sufficiently long. The temperature of the fluid should be at first 110° F., and may be gradually increased to 120°. Should the douching be followed by an increase of the pelvic pain or by faintness the temperature must be lowered. To prevent the too rapid escape of the water from the vagina, and so obviate the frequent filling of the douche can, the patient should keep her hand over the vulvar orifice and allow the fluid to escape at intervals. The douche should be taken in the horizontal position if possible, and should be followed by half an hour's rest in the same posture. It is not necessary to add any medicaments to the douching fluid unless there is any vaginitis or cervical catarrh, when the best solution to use is one of corrosive sublimate (1-3000).

After a week's douching in this way pledgets of wool soaked in glycerine, or in an 8 per cent solution of ichthyol and glycerine, should be introduced into the vagina and packed carefully round the cervix. These should be removed in twenty-four hours and immediately after a douche is given. Twelve hours later another douche is administered, and the glycerine plug again introduced. During a course of such treatment the patient should if possible rest in bed all the time; if this is not practicable, then for three or four hours each day flat on her back. The half-hour's rest after each douche should be strictly enforced.

The hot douche depletes the congestion of the uterus by stimulating uterine contraction and by causing a reflex contraction in the uterine blood-vessels. The glycerine plug acts by abstracting serum from the inflamed tissues, and its use is generally attended by a copious discharge which necessitates the patient wearing a diaper.

In some cases a complete cure will result from such a course of treatment, especially if the disease is of recent origin. In almost all there will be a marked relief from the general pelvic pain and discomfort. Much of the non-success attending the use of the vaginal douche and the glycerine plug in chronic pelvic inflammatory lesions is due to the altogether imperfect and perfunctory way in which they are employed. A patient who has been treating herself at home with no benefit will often improve rapidly if she is put under the supervision of a nurse who carries out the treatment properly.

Blisters over the hypogastrium and iodine applied to the roof of the vagina may be used in intractable cases, while hot fomentations and warm hip baths are beneficial in acute exacerbation of the inflammation which frequently occurs. Where the uterus is heavy and prolapsed, and bearing down pain is a prominent symptom, a soft vaginal rubber pessary will often give great relief. Applications of caustics to the endometrium and curettage are contra-indicated so long as the uterus remains tender. At a later stage, when bi-manual examination causes no pain, if there are indications of endometritis, the uterus may be curetted with benefit. The best hope of a permanent cure lies in the patient becoming pregnant and going to full time; the natural cure of chronic metritis which takes place in the puerperium being after all the only efficient one.

General Treatment.—All very active exertion, such as cycling, long walks, dancing, etc., should be forbidden. A moderate amount of gentle exercise in the open air is, however, beneficial. The importance of physical rest for at least three hours each day in the recumbent posture has been already referred to. Sexual rest is equally important. Intercourse should be entirely abstained from during a course of treatment. The value of the mineral waters of Kreuznach, Schwalbach, Wiesbaden, etc., on the Continent, and those of Woodhall Spa and Harrogate at home, in the treatment of metritis, as well as other chronic inflammatory pelvic lesions, is beyond doubt. It is, however, pretty generally admitted that much of the benefit which so often follows a visit to one or other of these places is a result more often due to the rest—physical, mental, and sexual—obtained there than to the specific qualities of the waters themselves.

Constipation is a common cause of pelvic congestion in the female, and should be carefully guarded against. In correcting it salines are specially useful in the disease under notice. Epsom salts and Carlsbad salts, or such mineral waters as Hunyadi Janos and Apenta, are well adapted to the majority of cases. They should be given well diluted in the morning half an hour before any food is taken.

Ergot, potassium iodide, mercury, and arsenic are drugs which have all been vaunted as remedies from time to time in the treatment of chronic metritis. With the exception of ergot, their effects in improving the condition are very doubtful. Ergot in many cases does do good. In others, by increasing the normal contraction of the uterus, its use may be attended with an increase of the pain. To get results from the use of ergot it is important to use only freshly made preparations. Much of the ergot which is dispensed is quite inert owing to decomposition.

Careful dieting and tonics are, of course, of great value when the general health is impaired. Alcohol is generally harmful, and should be used sparingly where, owing to extreme debility, it seems necessary. The Weir-Mitchell treatment of enforced rest in bed, isolation from friends, full diet, massage and electricity, is specially adapted to those cases of neurasthenia and hysteria dependent on chronic metritis. In long-standing cases where all other measures fail, total extirpation of the uterus may be necessary to give relief.

Chronic Endometritis.—Chronic inflammation of the mucous membrane of the body of the uterus is, like chronic metritis, rarely the consequence of an acute affection, but results more frequently from prolonged hyperæmia, and is subacute from its commencement.

Several varieties have been described by pathologists which are difficult in most cases to differentiate clinically. The glandular, where the glands are much hypertrophied and proliferated ; the interstitial, where there is great hyperplasia of the connective tissue elements only of the mucous membrane ; a mixed form, where both glands and connective tissue are involved. Endometritis fungosa is a rarer variety than these. Here the mucous membrane seems to consist largely of dilated blood-vessels. Endometritis exfoliativa is characterised by a shedding of the endometrium, sometimes in the form of shreds, sometimes of a complete cast of the uterus. It is the same as membranous dysmenorrhœa. Finally, there is an atrophic form of endometritis met with after the menopause in old women, and which is of great importance clinically, from the fact that the foul-smelling discharge which characterises it may often lead to the suspicion of intra-uterine malignant disease.

Etiology.—The causes of chronic endometritis are the same as those mentioned as operating in producing chronic metritis, with which it is very often associated, though in the majority of cases it occurs as a separate affection. It is found both in parous and nulliparous women, though much more frequently in the former than in the latter, and, as above stated, it occurs in one form in old women subsequent to the climacteric. Scrofula, tuberculosis, syphilis, anæmia, rheumatism, and gout are said to be predisposing causes. This is somewhat difficult of exact proof, but it is equally certain that those cases associated with a tubercular or rheumatic diathesis are the most intractable. Gonorrhœa accounts for a small proportion of cases.

Symptoms.—The symptoms which characterise it are : (1) Menorrhagia. In but few cases is this symptom absent. It may manifest itself by an increase and prolongation, or too frequent recurrence of the menstrual flow. In very rare cases the menstrual flow may be lessened. In these the diminished discharge is of a dirty brown colour, and is much more offensive than normal. (2) Intermenstrual discharge. This may be leucorrhœal, sanguinolent, or muco-purulent, and is often so acrid as to cause excoriation externally, or be the cause of intolerable pruritus vulvæ. (3) Dysmenorrhœa. This is not a constant symptom by any means, and is probably only present in those cases where there is also some degree of metritis. (4) Pain in the back is commonly present, and is often the most distressing symptom. (5) Endometritis is also a common cause of sterility, and perhaps the most frequent cause of abortion.

Physical Signs.—On bimanual examination the uterus is felt to be enlarged and tender on pressure. The sound passes into the uterine cavity for a greater distance than the normal 2½ inches; its introduction causes pain and frequently a small amount of hæmorrhage. In rare cases the irregularities of the mucous membrane, as in endometritis fungosa, may be detected by the sound. The speculum shows a watery discharge, which has an alkaline reaction, coming from the cervix. Endometritis of the body is, however, generally accompanied by cervical endometritis, and the watery discharge is not often seen alone. More commonly there is a thick, tenacious mucus which results from the cervical affection. Endometritis is very common in a uterus which is retroflexed.

Differential Diagnosis.—Small polypi—mucous and fibroid—early malignant disease—carcinoma, sarcoma, and deciduoma malignum—and the retained products of conception—may all simulate chronic endometritis in their symptomatology and physical signs, and have to be differentiated from it.

This can only be done in many cases by dilatation of the cervix and exploration of the uterine cavity by the finger, or the examination under the microscope of scrapings taken by the curette. In connection with the latter the large amount of embryonic connective tissue which is present in the normal mucous membrane must be kept in mind, or many cases of simple interstitial endometritis will be mistaken for diffuse sarcoma.

Treatment.—Constitutional treatment, if indicated, will be along the same lines as the constitutional treatment of chronic metritis, and need not be repeated here. Local treatment by douching and vaginal tampons of glycerine may, in mild cases, be all that is necessary to effect a complete cure. In others we may apply iodine or some stronger caustic to the endometrium by means of a dressed sound. In the majority a thorough curettage and removal by this means of the diseased endometrium is the best and at the same time the speediest treatment. To be successful this must be done thoroughly after the cervix has been well dilated. The curetting is generally followed by the application of pure carbolic acid or a mixture of carbolic and iodine to the interior of the uterus.

If done thoroughly and in suitable cases curettage of the uterus is one of the most satisfactory of gynecological operations. The simplicity of the procedure has, however, led to the great abuse of this operation. (For further details of this operation see under "Curettage," vol. ii.).

Chronic Cervical Catarrh; Cervical Endometritis; Endocervicitis.—This is a chronic inflammatory process affecting the mucous membrane lining the cervical canal, and by many is said to be the most frequent disease of the female pelvic organs. It is frequently associated with corporeal endometritis, but occurs as a separate affection. It is also much more frequently met with in parous women than in nulliparæ.

The disease begins in the glands of the cervix, which in the early stages are found swollen, hypertrophied, and secreting very freely. Later the mucous membrane itself becomes greatly thickened by proliferation of the areolar tissue and congestion of its blood-vessels. Exfoliation of the columnar superficial epithelium of the cervical mucous membrane also takes place, and a single layer of delicate embryonic epithelium takes the place of that shed. As a result of the great hypertrophy and congestion of the mucous membrane it is thrown into numerous folds, and may extend outwards from the external os over a considerable extent of the vaginal surface of the cervix, the superficial squamous epithelium of which gives place to this new formation. The minute folds into which this hypertrophied membrane is thrown gives it to the naked eye a granular appearance, and as the thin epithelial covering allows the subjacent vascular tissue to shine through, the appearances presented on examination by means of the speculum are very similar to those of an ulcer, for which condition they were long mistaken. The red, raw-looking patches are in reality newly formed glandular secreting surfaces, and result from an ectropion of the cervical mucous membrane. True ulceration of the womb is one of the rarest of diseases.

The inflammatory process is not confined to the glands and mucous membrane, but extends also to the connective tissue of the cervix, so that in long-standing cases the cervix becomes much enlarged and thickened. Finally, it should be stated that the mouths of the inflamed glands frequently become obstructed, the secretion becomes inspissated, and retention cysts are thus produced. These are felt as hard, pea-like nodules, and constitute the so-called Nabothian follicles, and account in many cases for much of the enlargement and irregular shape of the cervix in cervical catarrh. On incision of these follicles as much as a teaspoonful of thick, glairy mucus may escape. When the glands are extensively involved we get a condition which has been described as cystic degeneration of the cervix.

Etiology.—Laceration of the cervix produced in parturition is undoubtedly the most important cause of cervical catarrh. As a result of the tear the mucous membrane is exposed to friction and irritation which leads to inflammation. It may be secondary to a vaginitis, the inflammation spreading upwards, or be an extension downwards of a corporeal endometritis. All the causes, therefore, of endometritis are also causes of cervical catarrh. It is also very commonly associated with backward displacements of the uterus. In nulliparous patients gonorrhœa is not an uncommon cause.

Symptoms.—In a simple uncomplicated case leucorrhœa is the outstanding symptom; pain and weakness in the back, irregular menstruation, and sterility are also generally present. To these may be added the symptoms of endometritis, as the two conditions so frequently occur together. Formerly it was supposed that many reflex disturbances, such as dyspepsia, neuralgias, convulsions, persistent salivation, profuse salivation, neurasthenic conditions, etc., had their origin in cervical catarrh. Now, however, it is generally believed that the importance of this condition in producing such symptoms has been greatly overestimated, and that if they do occur secondary to pelvic disease the cause is to be sought for rather in an accompanying metritis or diseased state of the appendages than in the cervical affection.

Diagnosis.—The examining finger on vaginal examination feels the enlarged, thickened, and generally lacerated cervix, scattered over which are the prominent Nabothian follicles. The everted mucous membrane is soft and velvety, and bleeds readily. The vagina is unusually moist from the excessive secretion. The speculum shows the fissured os surrounded by a red granular surface which looks like an ulcer, the true nature of which has been already stated. If the everted lips of the torn cervix are approximated by means of tenacula the greater part of this red surface will disappear and the extent of the laceration become more evident. A thick layer of tenacious mucus generally covers the inflamed surface.

Differential Diagnosis.—The leucorrhœa resulting from cervical catarrh has to be differentiated from that caused by vaginitis and corporeal endometritis. Examination by means of a Sim's speculum will, as a rule, be all that is necessary in the case of the former. Menorrhagia, with increase in the length of the uterine cavity, tenderness, and undue vascularity of the interior discovered on passing the sound, indicate the presence of endometritis. Of much greater importance is the differential diagnosis from early carcinoma of the cervix. This may be exceedingly difficult, for it has to be remembered that the simple condition not infrequently passes slowly into malignancy. Where there is any doubt, no time should be lost in excising a portion of the diseased tissue and having it examined microscopically.

This is really the only certain way of coming to a correct diagnosis in an obscure case. The age of the patient cannot be relied on in affording any reliable information. Cancer is often found in young women. The induration and distortion of the cervix produced by inflammation may both be closely simulated by an early malignant infiltration. Pain, too, is frequently absent in early cancer. In the later stages of malignant disease, when the tissue has begun to break down, there should be, of course, no difficulty. But we cannot afford to wait for this before forming a definite diagnosis, for it is only if recognised very early that malignant disease of the cervix offers any chance of successful treatment. (See also "MALIGNANT DISEASE OF THE UTERUS," p. 212).

Treatment.—Constitutional treatment here, as in other pelvic diseases, is of great importance, and should never be neglected. The patient should be encouraged to take out-door exercise, and very often a change of air will be beneficial. Tonics do good, and a strict attention to the diet and action of the bowels are necessary here as in endometritis. Complete sexual rest should be enjoined.

Locally, astringent douching of the vagina is of great value. The best astringent douche is corrosive sublimate solution, 1-3000; or 1-2000 sulphate of zinc (ʒj. to the pint) or copper sulphate (ʒij. to the pint) may be used instead. The temperature of the fluid used need not be over 112° F. Such a douche in a very short time has a marked effect on the leucorrhœa, and causes a shrinking and gradual disappearance of the catarrhal patches on the cervix. In nulliparæ, if the os externum is narrow, it should be notched to permit the escape of the mucus and allow the astringent fluid to reach the inflamed surface of the cervical canal. Retention cysts in the cervix should be punctured and their contents evacuated. The glycerine plug is useful here also. In many cases of cervical catarrh no further treatment than this is necessary. If, however, in spite of the astringent douches the leucorrhœa continues, direct application of pure carbolic or iodine may be made to the cervix. This should be done thoroughly once, and not repeated at intervals as was formerly done. Failing improvement after a single cauterisation, it is better to have recourse to operation. This may consist of a thorough scraping of the diseased surface, its removal by Schroeder's method, repair of the laceration by Emmet's operation, or, if there is great hypertrophy and induration, amputation of the vaginal portion of the cervix.

SUBINVOLUTION OF THE UTERUS.—The weight of the uterus after delivery is from one and a half to two pounds, and its length is about six inches, the fundus reaching as high as the umbilicus. In from four to six weeks, as a result of certain processes of absorption and transformation of tissue, the exact nature of which is still very imperfectly understood, it is returned to its normal size and weight and position in the pelvis which it occupied before pregnancy. The retardation or arrest of this process of involution after premature termination of pregnancy or delivery at term is known as subinvolution, a term first employed by Sir J. Y. Simpson.

Etiology.—The physiological process of involution is brought about by the diminished blood-supply to the uterus resulting from the intermittent contractions and permanent retraction of its muscle fibres after delivery. The causes of subinvolution are to be found, therefore, in conditions which tend to produce vascular engorgement, or which will interfere with the normal contraction of the uterus. First in importance, therefore, is the occurrence of pelvic inflammation. In all such cases involution is delayed and always arrested before the process is complete. The presence of pelvic tumours, backward displacements of the uterus, chronic constipation, hepatic and cardiac disease, and resuming the erect posture and active work too soon after delivery, all operate in the same way in retarding or arresting complete involution by causing congestion of the uterine vessels. Imperfect uterine contraction after labour is met with in cases where there has been undue hæmorrhage during delivery, where the labour has been unduly prolonged, in cases also where portions of the membranes or placenta have been left behind, and where there is retained blood-clot. An over-distended bladder may interfere with normal involution. Finally, imperfect contraction of the puerperal uterus is frequently met with in those cases where the normal stimulant to such contraction is not forthcoming owing to the patient not suckling the child. Premature labour, plural births, parturition late in life, chronic debilitative disease, such as phthisis, are often alleged but much less certain causes of subinvolution.

Diagnosis and Symptoms.—During the lying-in period observations should be systematically made as to the position of the fundus and size of the uterus. An early recognition of any arrest or cessation of the normal diminution is of the utmost importance, as appropriate treatment at this time may avert much subsequent suffering and discomfort. Considerable variations occur, but for practical purposes it may be stated that the fundus uteri on the day after delivery will be found at or slightly above the level of the umbilicus; on the third and fourth days just below the umbilicus; on the fifth and sixth days from two to three fingers' breadth below the umbilicus; on the seventh and eighth days midway between umbilicus and symphysis; and on the tenth and eleventh days at the level of the symphysis. By the end of the sixth or eighth week the process of involution is complete. The parous uterus is always slightly larger than that of a nullipara. Delayed or arrested involution is associated with an increase and prolongation of the bloody lochia, and in those cases where the cause is a piece of retained placenta or membrane the discharge may remain coloured for weeks. The diagnosis of subinvolution is, however, generally not made until long after the patient has passed out of the puerperal state. The symptom which, in the majority of cases, causes the patient to seek advice is an undue loss of blood at the menstrual periods. This, in fact, is frequently the only symptom. In others there is also a feeling of weight and discomfort in the pelvis or actual bearing-down pains. Leucorrhœa is present when there is endometritis. Rectal and bladder troubles may be complained of, especially when the uterus is displaced backwards. Dysmenorrhœa exists only when there is metritis or congestion of the ovaries.

As regards the reproductive system, it has to be noted that subinvolution tends to cause sterility, probably on account of the diseased state of endometrium, which is so frequently also present. In the event of a fertilised ovum finding a lodgment in such a uterus there is a great tendency to abortion. The cause of the so-called "abortion habit" is very often to be found in subinvolution.

Physical Signs.—On vaginal examination the cervix will be found enlarged and thickened often at a lower level than normal, the heavy uterus tending to prolapse. Bimanually the uterus is found enlarged and often retroflexed. The sound passes into the uterine cavity more than 2½ inches, and its introduction generally causes pain.

Subinvolution has to be differentiated from the following conditions, in which there is enlargement of the uterus:—

1. *Pregnancy before the Third Month.*—The amenorrhœa and morning sickness, and the soft, boggy consistence of the uterus in early pregnancy, will in most cases be sufficient to enable one to distinguish an early gestation from the hard, subinvoluted uterus. Subinvolution, however, in a lactating woman, when menstruation is in abeyance, may very easily be mistaken for an early pregnancy by one who is not skilled in the bimanual examination of the uterus. When any doubt exists a definite diagnosis should be withheld for a month, by which time the growth of the uterine swelling and the development of some of the other signs of pregnancy will make the case clear.

2. *Small Fibroid Tumour.*—A small intra-mural or submucous fibroid which does not produce any distortion in the form of the uterus. Not only an increase in its size may so closely simulate in its symptoms and physical signs subinvolution, as to make a correct diagnosis impossible until the case has been under observation for some time; the hæmorrhage is likely to be more severe in the case of the fibroid, especially when it is submucous or polypoidal.

3. *Chronic Metritis.*—This condition is by many authorities considered to be the same pathologically as subinvolution, but while it is probable that the one condition frequently merges into the other, there is sufficient evidence clinically to warrant their being considered as separate diseases. In subinvolution the uterus, though enlarged, is not tender. In chronic metritis there is much greater pelvic pain, and dysmenorrhœa is always a marked symptom. Menorrhagia is always present in subinvolution, while it may be altogether absent in chronic metritis in its later stages. Finally, we may meet with well-marked metritis in nulliparous women.

Treatment.—From what has been said as to the etiology of subinvolution, it will be seen that preventive treatment is of the first importance. Strict antisepsis is to be observed during labour and in the lying-in period. Care should be taken that no part of the placenta is left in the uterus after labour or abortion. The patient should not be allowed up too soon, and constipation in the puerperium is to be guarded against. As regards the measures to be adopted when the condition is already present, these are all to be directed towards relieving the congestion and engorgement of the uterus, which is always present, and though it is questionable if any treatment will succeed in making the uterus smaller when the puerperal period has passed, still many of the symptoms may be relieved and a partial cure at any rate effected. General or constitutional treatment is often more indicated than local remedies. Mineral and vegetable tonics, iodide of potassium, ergot, given over long periods, and the mineral waters of Kreuznach, etc., are all useful. In weak, debilitated women, where the general nutrition is poor and little food is taken, cod-liver oil and iron are indicated. In all cases a saline aperient draught each morning does good.

Local remedies include the use of the hot vaginal douche—to which some astringent may be added if there is also a relaxed and subinvoluted condition of the vagina and pelvic floor—and the glycerine plug. These remedies have largely replaced the former treatment of applying caustics to the endometrium and the application of leeches to the cervix, and if properly carried out as directed under the local treatment of chronic metritis, rarely fail to do good. Electricity, used in the same way as in the treatment of uterine fibroids, is also a valuable therapeutic remedy. Under its use the uterus often becomes distinctly smaller, and the menorrhagia lessen if not entirely disappear. When the uterus is displaced the first step in treatment will, of course, be the correction of the displacement and the retention of the uterus in its normal place by operation or the use of a vaginal pessary. When endometritis is present the uterus should be curetted; and when the cervix is deeply lacerated and inflamed, attention must be directed to the cure of these conditions. Amputation of the cervix in subinvolution was formerly a popular method of treatment. It has, however, decidedly fallen into disuse. Should a patient with a subinvoluted uterus become pregnant the greatest care should be taken to prevent an abortion, for it is in the succeeding puerperium that we will look for the only safest cure of this troublesome condition.

SUPERINVOLUTION OF THE UTERUS.—Very rarely the process of involution after delivery does not stop at the restoration of the uterus to its normal non-pregnant size, but continues, and as a result the organ remains permanently small. To this condition Sir J. Y. Simpson applied the term superinvolution. It is also known as puerperal atrophy.

Etiology.—This is obscure. Prolonged lactation is said to cause it, and from the relative frequency with which the condition is met with among the poorer classes, this is probably correct. Excessive loss of blood during labour is said to favour its occurrence, and it is more commonly met with in weak, anæmic patients than in those who are well nourished and full blooded. A form of atrophy of the uterus in the puerperium may be caused by an obstruction to its proper blood-supply in the cicatrisation of inflammatory exudations in the broad ligament. This, however, though puerperal, is hardly the same condition as superinvolution.

Symptoms.—Amenorrhœa, relative or complete, and sterility are the only symptoms of this rare affection. The diagnosis is made by bimanual examination of the uterus, when its small size will be noticed. If the sound is used it will be found to go into the uterus only for a distance of 2, or it may be only 1½ inches. The prognosis as regards the possibility of a patient with superinvolution becoming again pregnant is decidedly unfavourable, but should always be very guarded. The writer has had under his care a patient whose uterine cavity was less than 1¾ inches in length, and who had not menstruated for more than one day at a time, and for months not at all, who was subsequently delivered of a healthy child at term.

Treatment.—This is very unsatisfactory. The galvanic stem pessary introduced by Sir J. Y. Simpson for stimulating the atrophic uterus to further growth probably does no good, and its use is not free from danger.

A more rational and safer treatment is the direct application of electricity by means of one pole inside the uterus, the other over the abdominal wall.

IV. Non-Malignant Tumours of the Uterus.

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SIMPLE TUMOURS, "FIBROIDS," ETC.

"FIBROIDS."—Under this heading are included all those tumours of the uterus in which white fibrous tissue and muscular elements in varying proportions form the bulk of the tumour. It is simply a convenient term to describe a group of pathological growths, for under it are included tumours which have very dissimilar composition, histories, and symptoms. The word fibroid in this article is used in this sense only. Several classifications of fibroids are in use. In one the composition and manner of growth supply the basis, and the growths are described as:—

1. *Fibro-Myomata or Multiple and Multinodular Fibroids.*—In these tumours the white fibrous tissue predominates over the muscular elements. They are hard, and are usually present in numbers in the same uterus.

2. *Myo-Fibromata or Uninodular Fibroids.*—These tumours are softer, because they have more muscular tissue in their composition. They should be subdivided into—(*a*) the encapsuled; (*b*) the non-encapsuled.

The encapsuled sub-variety is often many whorled and comparatively hard; while the non-encapsuled consist not of whorls but of an intricate mesh-work of muscular and fibrous tissue more or less inseparably blended with the normal musculature of the uterus.

A second classification is based on the position of the tumours with reference to the wall of the uterus, thus:—

(1) Sub-peritoneal: (*a*) sessile; (*b*) pedicilated.
(2) Interstitial.
(3) Sub-mucous: (*a*) sessile; (*b*) polypoid.

Frequently in cases of multiple fibroids all these varieties are illustrated.

A third classification has reference to the point of origin of the growth with reference to the region of the uterus—such as fibroids of the body, fibroids of the cervix.

Pathologically the first classification is the most important.

1. *The hard, multiple fibro-myomata* consist chiefly of white fibrous tissue arranged in whorls, in the interstices of which lie unstriped muscle fibre cells with elongated nuclei resembling the muscle cells of the normal unimpregnated uterus. The whorls vary in size, from those seen only through the microscope, to others having a diameter of several centimetres. A varying number of whorls packed together, and usually surrounded by a loose musculo-fibrous capsule, constitute a tumour. The blood-vessels ramify chiefly in the capsule, the interior of the growth being almost non-vascular.

The naked-eye appearance of a fibro-myoma is that of a firm white mass, the cut surface of which shows the whorled arrangement of its fibres and has been compared to "white watered silk."

The capsule really consists of altered and condensed uterine tissue. It is therefore attached loosely to the growth, but intimately to the uterus. This peculiarity often facilitates the enucleation of the morbid from the normal tissues.

The fibro-myomata are probably all interstitial in origin. They commence in the musculature of the uterine wall and grow in the direction of least resistance, being pushed by the contractions of the normal muscle outwards towards the peritoneum or inwards towards the mucous membrane lining the uterus. They may be found deeply embedded in the wall, or covered only by peritoneum or by mucous membrane.

The fibro-myomata, like their component whorls, differ greatly in size. They vary from a minute size up to a huge tumour weighing more than 30 kilogrammes, or upwards of 70 lbs. The numbers vary in each case examined; there may be two or three separate tumours or there may be hundreds.

2. *The Myo-Fibromata.—Synonyms:* soft fibroids; uninodular fibroids; monomata; non-encapsuled fibroids.

These tumours appear as pinkish masses of varying degrees of softness embedded in the uterine wall.

They contain a larger proportion of muscular fibres and relatively less fibrous tissue than do the multinodular or hard fibroids. The more abundant the muscular tissue the softer and the pinker the mass. They are also richer in blood-vessels, which permeate their tissues and are not confined to their periphery. These growths frequently have no capsule, they cannot be readily enucleated from the surrounding uterine tissues, and they are usually deeply embedded because they stimulate the normal tissue to over-development.

Some of the uninodular fibroids are so soft that clinically they are mistaken for cystic growths. Their tissues are not arranged in whorls, but form an interlacing network more or less continuous with the normal tissues of the organ.

The life-history is different in the two great classes of fibroids. Both varieties may exist from very early days, but occur most frequently during the child-bearing period of life. The hard fibromata follow closely the life-history of the uterus itself. They develop during its period of functional activity; they frequently enlarge to a noticeable degree before and during the catamenia, becoming smaller during the intermenstrual epoch; they often grow enormously during pregnancy, in correspondence with the remarkable physiological hypertrophy and hyperplasia of the uterus; after parturition they share in the rapid involution of that organ. In rare cases the tumour may even disappear; and, lastly, although the menopause may be long, and indefinitely, delayed in the presence of fibroids, yet when it is established the tumour may, like the uterus, undergo senile atrophy. Lastly, these tumours often dwindle after the artificial menopause caused by ablation of the ovaries and tubes.

The soft myo-fibromata have a life-history entirely independent of that of the uterus. It is true that they are very rare before puberty, but so are other tumours. If a young girl has a fibroid at all it is usually of the soft, solitary variety. They are often unaffected by menstruation; alter little during pregnancy and after parturition; they grow on steadily unaffected by the menopause, and, indeed, often appear for the first time after the reproductive period of the uterus is over. Their growth is unaffected by the removal of the uterine appendages. This independence of growth and other characters show that soft, non-encapsuled fibroids are more nearly allied to malignant growths than are the hard fibro-myomata.

With regard to the destiny of an individual fibroid, it may remain interstitial and evolute, involute, or degenerate *in situ*. It may be gradually pressed towards the peritoneum, and be excentrically extruded so as to form a rounded mass raised above the general peritoneal surface of the uterus. If the process continue the fibroid may be entirely expelled from the uterus and hang free in the peritoneal cavity. Eventually such a fibroid may be entirely detached so as to be found lying in Douglas's pouch; or it may acquire attachments to various pelvic or abdominal organs. Fibroids attached to the uterus by a long pedicle sometimes cause obstruction of the bowels by strangling a coil of intestine, or they may lead to severe pressure symptoms by falling into Douglas's pouch when the patient stands up. The recognition of this accident is facilitated by the cessation of symptoms when the fibroid is pushed up, and when the patient lies down or assumes the knee-face position.

In another class of case the direction of growth and the uterine contractions may force the tumour concentrically towards the uterine cavity, so that under favourable circumstances it becomes polypoid. The pedicle at first consists of a layer of uterine muscle covered with mucous membrane, but after a time it is formed by attenuated mucous membrane only. Having thus become pedunculated, the growth is called a polypus. At any stage this process of pedicilation may be arrested, and the bleeding and other symptoms may become so severe as to destroy life unless relieved by operation.

Thus the submucous fibroid is liable to cause excessive hæmorrhage and discharge owing to the accompanying congestion of the uterine mucosa; it may become infected and undergo sloughing, gangrenous, or suppurative changes. It may undergo an imperfect process of enucleation in the course of which its vitality is lost, its capsule ulcerates, and it is discharged piecemeal, the patient meanwhile developing symptoms of sepsis. The danger is less, and the chance of complete spontaneous expulsion is greater, when the suppurative or other destructive change involves the capsule only. The maximum of danger arises when the substance of the tumour undergoes one of the destructive degenerations. The whole system of muscles connected with the uterus is liable to the development of "fibroids." They have been found in the round ligament, the ovarian ligament, and in the broad ligament, not merely as extensions of a tumour originating in the uterus, but as independent growths.

Symptoms.—(*a*) Symptoms may be due to the tumour itself. These seldom arise so long as its tissues are in good health.

(*b*) The commonest symptoms are due to alterations in the uterus and other organs caused by the tumours, and to secondary changes produced in them.

Hæmorrhage.—The commonest symptom of both hard and soft fibroids is hæmorrhage. It occurs both as menorrhagia and metrorrhagia, and varies from a slight increase in quantity or frequency of the normal loss to dangerous floodings. The hæmorrhage proceeds from the mucous membrane of the uterus, and may be due to its abnormally increased area, to the supervention of endometritis, or to the coexistence of fibroid or mucous polypi. The hæmorrhage is most abundant when the tumour is immediately beneath the mucous membrane, and may be slight, or even absent, when the growth is entirely subserous. So long as the tumour remains in the uterus the hæmorrhage usually observes the monthly rhythm and may be called menorrhagia. Should the tumour be extruded into the vagina, the hæmorrhage, whether slight or profuse, tends to be remittent or continuous and is a metrorrhagia. Hæmorrhage sometimes, but rarely, proceeds from the capsule of the tumour, as in cases of submucous fibroids, where the mucous membrane has been perforated by the growth so that the tumour presents at the os uteri. In a case recorded by Matthews Duncan the capsule of the tumour had calcified, subsequently this shell cracked and wounded a large sinus producing an immediately fatal hæmorrhage.

The amount of hæmorrhage varies greatly in different cases, some patients with a large tumour losing little, while others in whom the growth is small suffer absolute floodings. The character of the growth does not explain these variations, as they occur alike in uninodular, multinodular, and multiple fibroids. Certainly the approach of the growth to the mucous membrane appears to be accompanied by increased hæmorrhage while the symptom is usually less formidable, and may even be absent, when the tumours are subperitoneal only.

Pain is not so common a symptom in fibroids as is hæmorrhage, and when present is often associated with some morbid change in the tumour, or with injurious effects produced by it on other organs. It is usually described as a dull grinding pain, sometimes as a sense of over-fulness or twisting, and sometimes as colicky or paroxysmal. This intermittent rhythmical pain is most frequent when the tumour is pressing on, or through, the cervix. It is natural that it should thus simulate the pains of the first stage of labour.

Pain may be due to the following causes:—

1. The involuntary extrusive efforts of the uterus by which an intramural growth is forced towards the mucous or the serous surface.

2. The dilatation and stretching of the cervix uteri during the extrusion of a fibrous polypus.

3. The incarceration of a fibroid uterus, or of a pedunculated subserous fibroid, in the bony pelvis, causing pressure on adjacent organs and nerves.

4. Interference of the growth, or its pedicle, with other pelvic or abdominal organs by which morbid changes are caused in them.

5. The sense of weight and bearing down usually present is aggravated into pain during the catamenia. This is most marked in the case of submucous growths, and is then probably due to exaggeration of the normal congestion. The same symptoms may occur even when the growth is subserous, and is then explained by the fact that the swelling due to normal increase of vascularity is hindered by the tension of the capsule.

Any marked increase of pain—or its appearance as a new symptom—demands careful investigation, as it is frequently the first warning of degenerative changes occurring in the tumour (see Indications for Operation, page 198).

Discharge of a watery or mucoid nature, not blood-stained and not offensive, is a common symptom. It is due to concurrent congestion of the general mucosa of the uterus, or sometimes to over-stimulation of the cervical glands. Purulent, blood-stained, and offensive discharges are usual in sloughing, inflammatory, sarcomatous, and other destructive degenerations, also when there are certain complicating or coexisting diseases, such as purulent endometritis or epithelioma.

Bladder symptoms, especially incontinence or retention of urine, are common in cases of fibroid growths. Cystitis is not common. These symptoms are due to pressure. Retention generally results from pressure of an intra-pelvic mass on the urethra, while incontinence is more commonly caused by pressure of an intra-abdominal growth on the bladder.[1]

Rectal symptoms of fibroids (which are much less common than bladder symptoms) are also due to pressure. Constipation may exist from direct pressure of a growth when intra-pelvic, or from increase of general abdominal pressure in the case of large tumours. Hæmorrhoids are caused by pressure on the veins of the rectum. The patient may also complain of tenesmus and of mucoid discharge from the bowel.

Variations in size may be very slow, as in the majority of the hard fibromata, or relatively rapid, as in the softer variety. Sudden increase in size should always excite suspicion of some untoward change in the growth. The rate of growth is uncertain, as there are no means of fixing the time of its commencement. Each case must be watched carefully and judged on its merits.

The size of the tumour may also vary from time to time spontaneously to a remarkable degree. A decrease may be observed after rest in bed, more frequently after a profuse period, and after parturition, sometimes after a merely exploratory laparotomy.

Sterility is frequent in women afflicted with fibroids, and may be explained in part by the endometritis which is often present, and in part by the frequent complicating diseases of the ovaries and tubes. In another group of cases conception occurs, but abortion or miscarriage supervenes. Lastly, pregnancy may be ended intentionally or accidentally by surgical interference. On the whole, fibroids appear to be more common in sterile than in fertile women.

A venous hum, resembling the souffle heard during pregnancy, may be sometimes recognised in cases of fibroid tumours. Probably it is due to the rushing of the blood in the large sinuses of the capsule.

One or more of these symptoms, such as hæmorrhage, pain, and discharge, may combine to present us with a typical clinical picture.

In the early stages of a fibroid's career there may be no distinctive symptoms, and the small tumour may be discovered by accident when the patient is examined for a supposed displacement, or to ascertain whether an early pregnancy exists. In some cases this absence of marked symptoms persists, and the patient remains in good health, even though a large tumour is present. In many cases, however, the patient gradually becomes anæmic, with pale skin, white lips and mucous membranes, the ears look as if modelled in pale yellow wax. She is breathless on exertion, and complains of faintness, palpitation, and dyspepsia. If the disease continues unchecked and pain coexists with hæmorrhage, the woman is still more wretched. She suffers from loss of sleep and rest, from want of appetite, and from nervous debility. At last, even if the tumour undergoes no degenerative change, and no serious complication appears, the patient becomes a chronic bed-ridden invalid.

COMPLICATIONS *of Fibroids.*—Most authors agree that the percentage of complications in cases of fibroids is large.

Twambly (*Boston Medical and Surgical Journal*, May 1897) estimated that 50 per cent of the cases of interstitial fibroids were accompanied by disease of the Fallopian tubes.

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[1] Hydro-ureter, hydro-nephrosis, pyo-nephrosis, and other destructive changes in the kidneys are less common in cases of fibroids than in cases of cancer uteri. They do, however, occur, and generally in cases in which the broad ligaments are invaded by the growths.

Meredith, analysing Tait's cases (*Brit. Med. Jour.* 1890), found 54 per cent tubal disease and 46 per cent chronic ovaritis. Lately three analyses gave the following results :—

Dr. Ch. Noble. 218 Consecutive Cases.		Dr. Ch. Cullingworth. 100 Consecutive Cases.		Mrs. Scharlieb. 100 Consecutive Cases.	
Hydrosalpinx	13	Hydrosalpinx	5	Hydrosalpinx	4
Pyosalpinx	8	Serious adhesions	12	Pyosalpinx	1
Hæmatosalpinx	1	Dilated ureters and hydronephrosis	1	Adhesions	6
Salpingitis	7	Dilated ureters, hydronephrosis, suppurative pyelitis, etc.	1	Cysts or cystomata	23
Ectopic gestation	3	Ectopic gestation	1	Parovarian cysts	2
Ovarian cysts	27	Twisted pedicle	2	Thrombosis, before operation	2
Ovarian abscess	1			Varicose veins of pelvis	4
Parovarian cysts	2			Fibroma of Fallopian tube	1
				Papillomata of appendages	1
				Incarceration of tumour	5
				Pregnancy	1
				Appendicitis	1

These pelvic complications may bear relation to fibroids as being coincidents or effects—probably they are most frequently effects. The tumour interferes with the pelvic circulation and frequently dislocates the organs. When it is situated in the fundus or the posterior wall of the uterus it may cause retroversion or retroflexion, and the appendages are thus dragged out of their normal position.

Pregnancy is one of the gravest complications of fibroids, partly from the enhanced risk of mechanical obstruction during parturition, partly from the increased risk of post-partum hæmorrhage, and partly from the danger of bruising or other injury impairing the vitality of the tumour (see Indications for Operation, p. 199).

Adhesions are a fairly common, and may be a very formidable complication. They occur after peritonitis however excited, (1) by extension of inflammation from the tumour itself, or (2) in consequence of inflammation of neighbouring organs, and (3) in cases where treatment by electrolysis has been tried. Adhesions are common, tough, and abundant where the sharp electrode has been plunged into the tumour or into the normal uterine tissue in which it is embedded.

Phlebitis, phlegmasia dolens, thrombosis, and embolism occur both during the existence of fibroids and after operation for their removal. These complications are due to pressure on the veins, and other interference with the circulation; to septic absorption when the tumour has undergone degenerative changes; to feebleness of the heart's action; and to altered constitution of the blood, especially in cases where there has been much depreciation of vitality as a result of excessive hæmorrhage, severe pain, etc.

Parotitis is not common, but when it occurs in connection with degenerate fibroids it is usually suppurative, as in other cases of abdominal disease or operation.

Heart disease is a fairly common complication of fibroids. It especially occurs as dilatation, hypertrophy, fatty and brown degeneration of the musculature.

Fatty enlargement of the liver has been observed, and is noted by Dr. Bantock.

Derangements of the urinary apparatus are among the most serious and common of the complications of fibroids, and are most likely to occur when there is incarceration of the uterus and tumour, or of the tumour alone, within the bony pelvis, especially when the broad ligaments are invaded. The symptoms then resemble those of the incarcerated retroverted gravid uterus (vol. x. p. 40).

Retention and incontinence of urine have been already mentioned, and although secondary changes in the kidneys, due to disease of the bladder or to pressure of a fibroid on one or both ureters, are not so common as in cancerous disease of the pelvic organs, they occur with sufficient frequency to cause great anxiety to the surgeon.

Pressure on the intestines, especially on the *rectum,* already mentioned (p. 193).

Pseudo-sciatica and other neuralgic pains due to pressure on the pelvic nerves ought to draw the surgeon's attention to the condition of the pelvic viscera. Not infrequently a pain in the course of one of the pelvic nerves, which has resisted diagnosis and treatment, will be explained by the discovery of a fibroid or other tumour. Relief will follow treatment based on a correct diagnosis.

DEGENERATIONS *of Fibroids.*—This term is limited to morbid alterations in the tissues of the tumours and does not apply to coexisting disease. Thus epithelioma of the cervix is a complication but not a degeneration of a coexisting fibroid situated in the body of the uterus.

The following table appears to include all the known forms of "degeneration," and is satisfactory in so far that the classification is fairly accurate both pathologically and clinically:—

A. *True Degenerations*—
   1. Simple aseptic necrobiosis.
   2. Suppuration.
   3. Sloughing.
   4. Œdematous change and myxomatous degeneration.
   5. Calcareous degeneration.
   6. Fatty degeneration.

B. *Transition to other Forms of Growth in Fibroids*—
   1. Sarcomatous growth.
   2. Carcinomatous growth.
   3. Teleangiectatic growth.
   4. Lymphangiectatic growth.

C. "*Cystic*" *change in Fibroids*—

This is not a pathological entity, but includes cystic development caused by—
   1. Cavities (pseudo-cysts) due to the softening produced by necrobiosis, suppuration, œdematous, and myxomatous change, or as the result of hæmorrhage into soft fibroids or sarcomata. These cavities have no epithelial lining.
   2. Cavities formed by teleangiectasis or lymphangiectasis, lined by endothelium.
   3. True cystic fibroids, in which the cysts are formed by glandular elements within the tumour and are lined by columnar epithelium.

Under these headings it is possible to group the degenerations noted in practice by several authors, and it is to be hoped that a more careful and systematic examination of all tumours removed by operation or post-mortem will lead in time to a fuller understanding of these important changes, and consequently to wiser advice and better treatment.

	Noble. 208 Cases.	Martin. 205 Cases.	Cullingworth. 100 Cases.	Scharlieb. 100 Cases.
A. *True Degenerations*—				
1. Simple necrobiosis	12	...	15	
2. Suppuration	...	10	3	2
3. Sloughing	...	...	...	3
4. Œdematous and myxomatous	5	11	27	5
5. Calcareous	5	3	1	2
6. Fatty	...	7		
B. *Transition to other Forms of Growth in Fibroids*—				
1. Sarcomatous	2	6	1	6
2. Carcinomatous				
3. Teleangiectatic	...	2	...	1
4. Lymphangiectatic				
C. *Cystic Changes in Fibroids*—				
1. Pseudo-cysts (cavities due to softening)	5	1	5	7
2. Cavities formed by teleangiectasis, etc.				
3. True cystic fibroids				

The above table is evidently very imperfect, as, for instance, none of the observers have sufficiently indicated the varieties of cysts; it is published only in the hope that in future classification may become more accurate.

A. *True Degenerations*

1. *Simple aseptic necrobiosis* occurs in tumours in which the blood-supply is absent or deficient, but to which septic germs have not acquired access. The tumours in such cases have probably been badly supplied with nourishment from the first, and consequently a comparatively slight interference with the vessels stops the supply altogether.

2. *Suppuration.*—The change may depend on inflammation commencing in the tumour itself, or on extension to it of morbid changes from neighbouring organs, such, for instance, as the vermiform appendix, the ovaries, or tubes. In this degeneration some micro-organism plays a part, for instance the streptococcus, staphylococcus, gonococcus, the bacillus of tubercle, or the bacillus coli communis. The process must not be considered identical with sloughing or gangrene.

3. *Sloughing* may attack fibroids in many ways by interference with their vascular supply, mechanical injury, or the invasion of septic organisms. These conditions, singly or combined, are seen under the following circumstances among others:—

(1) As a result of bruising or other injury during childbirth, either from the muscular contractions necessary to the process, from pressure of the child's head, or as the result of assistance, manual or instrumental.

(2) As one effect of puerperal septicæmia—the micro-organisms or their toxins obtaining access to the tumour and interfering with its vitality.

(3) As the result of operations intended for the removal of the tumour.

(*a*) Submucous enucleation, where the capsule has been injured and the uterus left perforce or designedly to expel the tumour.

(*b*) Electrolysis, where the cauterising effects of the intra-uterine electrode injures the endometrium and opens the way for pathogenic micro-organisms, or compromises the vitality of the tumour by interfering with its supply of blood. In cases where a sharp electrode is plunged through the endometrium and the intervening tissues into the tumour, the injury is designed to produce a local disintegration of tissue which in so badly vascularised a tumour is likely to lead to generalised destructive changes.

(*c*) Result of extension from neighbouring organs, as in cases of disease of the pelvic and adjacent abdominal organs; especially in suppurative diseases of the ovaries, tubes, and appendix vermiformis. In some cases where no evident disease can be found it seems probable that infection by the bacillus communis coli may occur.

(*d*) Infection through the blood-supply, as in the acute exanthemata, influenza, etc.

(*e*) From incarceration of the tumour and uterus (resembling the condition of incarcerated retroverted gravid uterus), or from the incarceration of a pedunculated subperitoneal fibroid which has slipped behind the uterus and gives rise to urgent and distressing symptoms resembling those of strangulation of a viscus.

4. *Œdematous and Myxomatous Degeneration.*—Probably the term myxomatous is not always correctly used. In the majority of cases the fluid contained in the interstices of the tumour is serum rather than mucus. In some tumours, no doubt, there is myxomatous degeneration, but this is a different sort of change, and should not be confounded with an ordinary œdema (see Stanmore Bishop's *Uterine Fibro-Myomata*, 1901.)

5. *Calcareous degeneration* occurs (1) in the capsule (calcification *en coque* of Matthews Duncan), also (2) throughout the tumour commencing from the centre and extending to the circumference. The deposition of salts, chiefly of phosphate of lime, may be so general that the sawn surface of the tumour presents a uniformly hard surface capable of taking a high polish, or it may be partial, so that the cut surface presents a coral-like appearance, the calcified portions persisting while the fluid or soft solid which filled the interstices has disappeared. By calcareous degeneration are formed those curiosities of ancient medical literature known as "womb stones."

Calcification is due to deficiency in quantity or quality in the supply of arterial blood and is a true degeneration, such as is seen in the case of calcification of arteries. It is worthy of note that this change appears to be common in fibroids of long-standing that have been extruded from the peritoneal surface of the uterus and have maintained a precarious existence by adhesion to other organs.

6. *Fatty degeneration* may be primary, and in a sense "physiological" and curative, as when the tissues of a "fibroid" share in the physiological involution of the uterus and other pelvic organs after parturition and after the menopause, when some degree of fatty change appears to precede involution.

Fatty degeneration of fibroids may also be secondary and purely pathological; for instance, when it occurs as part of, or in the course of, other degenerations, such as the inflammatory, the necrotic, and the sarcomatous.

7. Lastly, some cases of gangrenous and other necrotic degenerations of fibroids are recorded as having occurred in women in good health and in whom no cause of injury to the tumour could be discovered. (See Cullingworth, *Journal of Obstet. and Gynæcol.*, January 1902). The explanation is difficult; probably the blood-supply to the tumour was inadequate for its nourishment, and infection from some unrecognised source reached the dying tissues.

B. *Transition to other Forms of Growth in Fibroids*

1. *Sarcomatous change* is recorded by all observers, and appears to be commoner than was formerly thought to be the case. It occurred twice in 208 cases reported by Ch. Noble, six times in 205 cases reported by A. Martin, once in 100 cases reported by Dr. Cullingworth, and six times in 100 cases reported by Mrs. Scharlieb. The difficulty seems to be to determine whether the connective tissue becomes replaced by sarcoma cells, or whether there is a sarcomatous invasion of the muscle

fibre cells (Discussion Obst. Society of London 1898, *Obst. Trans.* pp. 178 and 227).

2. *Carcinomatous change* is rare in fibroids, and from histological considerations is less to be expected than the sarcomatous. Still epithelial structures have been observed in fibroids, and are probably due in some cases to the nipping off by the growth of portions of the uterine glands which normally pass deep into the tissues. In other cases the epithelial tissues may be derived from aberrant remnants of the Wolffian body or the Mullerian duct.

The association of fibroids of the uterus with carcinoma or epithelioma of the body or cervix, though not uncommon, appears to be accidental. Of course the existence of the one disease is no bar to the development of the other, while both are common.

3. *Teleangiectatic change.*—In some cases not only are the ordinary vessels in the capsule and the uterine vessels themselves of enormous size, but the capillaries in the tumour appear to have become transformed into a network of sinuses somewhat like that existing in a pregnant uterus. They have no definite walls except a lining of endothelium, and are adherent to the muscular bundles. The portions of tumour that are thus degenerated are said to look "like a sponge engorged with blood." They furnish a loud venous hum such as is heard over the placental site, and may tend to obscure the differential diagnosis of the tumour.

4. *Lymphangiectatic changes* also occur. The lymph spaces between the bundles of fibres become dilated and filled with lymph, giving rise to one variety of fibro-cystic tumour.

C. "*Cystic*" *Change in Fibroids*

The term "cystic" fibroid has been applied to many different forms of cavities within fibroid tumours. The true cyst is that which is lined with columnar epithelium and which originates in some glandular elements enclosed within the tumour such as portions of uterine glands, or possibly from aberrant remains of fœtal structures. These cysts contain a secreted fluid, may attain a large size, and may be multiple. The cavities or pseudocysts which are formed by fatty, necrotic, myxomatous, or suppurative changes may also attain a large size, but their walls are ragged, irregular, and without epithelial lining, while their contents may be soft, necrotic, or gelatinous material, altered blood, or pus, according to the nature of the change which produced the cavity. The cavities which occur in teleangiectasis and lymphangiectasis have been described above.

Indications for Operations on Fibroids.—These will be discussed under the following headings:—

1. Hæmorrhage.
2. Pressure symptoms.
3. Rapid increase in size of the tumour.
4. Coexisting pregnancy.
5. Coexisting complications (such as disease of the pelvic organs or other viscera).
6. Sloughing and other degenerations of the tumour itself.
7. The patient's social position and moral considerations.

1. *Hæmorrhage* was long considered almost the only indication for operations on fibroids. Operations, except for removal of fibroid polypi

already extruded into the vagina, were seldom proposed until the profound anæmia and general debility were so marked that, operation or no operation, the patient was nearly sure to die.

Hæmorrhage may kill the patient directly, as in the case recorded by Matthews Duncan, but this is not common. Women have a remarkable, but not unlimited, power of making fresh supplies of blood. Frequently the fatal result is indirect, the woman being incapable in her exhausted and anæmic state of repelling attacks of illness or of convalescing from them. She is also liable to serious cardiac and vascular depreciation.

2. *Pressure symptoms* are most formidable when the tumour is incarcerated in the pelvis. They resemble those which occur in a case of retroverted or retroflexed gravid uterus. There is frequently retention of the urine due to pressure on the urethra or on the neck of the bladder. From time to time a little paralytic dribbling may occur, but the bladder is not relieved and requires the use of the catheter. Pressure on one or both ureters as they cross the pelvic brim may lead to hydro-ureter, and to further serious mischief in one or both kidneys (hydro- and pyo-nephrosis). Pressure on the rectum is seldom as painful or as prohibitive to function as in the case of pressure on the bladder, but it causes pain, constipation, tenesmus, congestion of the rectal mucous membrane and hæmorrhoids. Pressure on the pelvic nerves leads to various neuralgiæ, and especially to one form of pseudo-sciatica. Indeed, pain in the course of this nerve and its branches should always lead to careful examination of all the pelvic organs. Pressure on the ovaries and tubes, especially when they are prolapsed, produces a peculiarly sickening and intolerable pain. It also probably leads to many of the diseased conditions of these organs which are found in connection with fibroids.

When the fibroid has risen into the abdomen, pressure on the bladder more frequently causes incontinence than retention, and is often a great source of trouble and annoyance. The presence of a large fibroid in the abdomen affects the bowels, the liver, and other organs by the limitation of space and distortion of relations. Flatulent distension is sometimes specially distressing.

3. *Rapid increase in the size of the tumour*, especially when combined with pain, is one of the most important indications for operation. These symptoms arise in cases where the tumour is undergoing necrotic, suppurative, œdematous, myxomatous, cystic, sarcomatous, or carcinomatous change. The rapid increase in size is generally accompanied by constitutional symptoms, such as rise of temperature and pulse, with other signs of distress, and when the tumour is gravely degenerate the classical signs of septicæmia will usually develop.

4. *The coexistence of pregnancy*, though it does not invariably necessitate operation, is a very grave complication, the mortality being estimated at 36 per cent, including the cases in which spontaneous miscarriage occurs. Pregnancy must be considered both as an absolute and as a relative indication for operation. It is an *absolute* indication when, from the position of the tumour, delivery *per vias naturales* is impossible owing to mechanical obstruction, also when severe pressure symptoms develop. In some of the cases of retroverted gravid uterus plus fibroids with pressure symptoms, it may be possible to push the mass out of the pelvis, and, by posture aided by a suitable pessary, to retain it above the brim until the danger of incarceration is passed. Such an attempt at reposition must be made with great gentleness and caution, for many surgeons have reported cases where a rapidly fatal result followed successful attempts at reposition

—death under these circumstances being caused by contusion of the tumour or by torsion of its pedicle.

The coexistence of pregnancy and fibroids is a *relative* indication for operation, when mechanical obstruction is not feared, but where, from the position of the tumour, or from its size, the risks of parturition, whether premature or at full term, are great. The risks of hæmorrhage before, during, and after delivery must be considered; also the risks of injury to the tumour and consequent increased liability to septic infection.

Operations on fibroids during pregnancy do not always involve premature delivery nor the loss of the fœtus. In many cases of subserous fibroids removal can be effected with little or no injury to the uterus, and the mere fact of opening the abdomen seldom interferes with the normal course of gestation. In some cases hysterectomy may be indicated early in pregnancy, but only when the mother's life is obviously in danger. In another group of cases the operation can be postponed until full term. The child is then delivered by Cæsarean section, the uterus being removed or retained as seems most desirable in each case. See valuable papers by Cullingworth and Bland Sutton.

5. *Other complications*, some such as appendicitis, suppuration of ovaries or tubes, ovarian cysts, extra-uterine gestation, carcinoma of the body or cervix, are clear indications for operation in themselves apart from the coexistence of fibroids. Some complications, such as displacement of the uterus, phlebitis, and thrombosis, heart disease, insanity, and other nervous disorders, need careful consideration. Such factors as the patient's position in life, her ability to earn her living, and her general health, would count for much in these more doubtful cases.

6. *Degenerations of Fibroids.*—Of these the sarcomatous, suppurative, necrotic, gangrenous, cystic, and œdematous forms must be accepted as absolute indications for removal of the uterus and the tumour, unless the patient's general condition is so bad as to prohibit operation. Calcareous and fatty degenerations are sometimes absolute, sometimes relative indications, while the involution changes after parturition or the menopause, being conservative, do not call for surgical interference.

7. *Inability to work* in the case of women who must earn their living is generally accepted as an indication for operation, and surely it must be conceded that a woman, whose happiness and usefulness depend on her activity, has a right to demand relief when she prefers the risk of operation to the death in life of a "sofa existence."

8. Another indication which must weigh with surgeons is the misery inflicted by a large, heavy, and disfiguring tumour, which interferes with both the duties and pleasures of life, and excites much painful comment, and sometimes injurious suspicion.

FIBRO-CYSTIC TUMOURS OF THE UTERUS, see *ante* page 198.

POLYPI OF THE UTERUS

The term uterine polypus simply denotes the pedicilation of a mass with relation to the cavity of the uterus, and gives no information as to its nature or condition. The chief varieties of uterine polypi are—

1. The fibroid.
2. The adenomatous (so-called mucous).
3. The malignant—sarcomatous, carcinomatous.

4. The placental and fibrinous.
5. The papillomatous.
6. The tuberculous.

1. *Fibroid polypi* are submucous fibroids in process of extrusion. They appear to originate as interstitial fibroids. They grow in the direction of least resistance, and are also pressed towards the cavity of the uterus by the contractions of its musculature. Thus they become submucous, and, if the circumstances for their extrusion are favourable, they become increasingly prominent in the uterine cavity. They then approximate to the condition of a foreign body, and are gripped with increasing power by the uterine walls. Gradually they are extruded from their muscular surroundings, and their investment of mucous membrane is stretched and thinned at the base so as to form part of the pedicle. The mass is pressed against the internal os and gradually dilates it in the same manner as does an ovum. This resistance overcome, the same process is applied to the cervical canal until the polypus is forced through into the vagina. The main factors are the contractions of the musculature, the stretching of the mucous membrane (which sometimes gives way so that the fibroid is more or less denuded in its descent), the opening of the cervix, partly due to "polarity" and partly to softening from increased supply of blood and mucoid discharge. The whole process is analogous to that of parturition, although the parallelism of details must not be pressed. One feature of the process is that a polypus may be extruded during the increased action and softening peculiar to menstruation, and withdrawn into the cavity of the uterus during the intermenstrual period (intermittent polypus). The possibility of extrusion through the vulva depends on the length of the stalk, or on the dragging down of the uterus in the process of extrusion.

The histology and pathology of uterine fibroid polypi is identical with that of fibroids in general, but they are usually of the "hard" variety. The mucous membrane covering a polypus usually retains the columnar ciliated type and its glandular arrangement while the polypus is intra-uterine. It becomes stratified and squamous after the extrusion of the growth, except in recesses and crannies which are not exposed to pressure from the vaginal walls.

They are nourished by their envelope of mucous membrane, which, as it is stretched and thinned, becomes progressively less vascular. Large blood-vessels are seldom found in the pedicle. To this comparative deprivation of blood-supply is due the increased tendency to sloughing and gangrene observed in submucous and polypoid fibroids. Hence if delayed in the canal of the cervix, or at the os uteri, the part of the tumour beyond the constriction is deprived of nourishment and exposed to the invasion of micro-organisms; it is therefore in the most favourable condition for degeneration.

In size fibroid polypi vary from that of a walnut, or even less, to that of the uterus at full time; in one case such an extruded tumour was mistaken by an Indian midwife for a monstrous birth. The extrusion through the pelvis occupied a week, and as it was completed the patient died. The tumour was the size and shape of a uterus at term.

Usually fibroid polypi lie free in the vagina, or in the circle of the os uteri; exceptionally adhesions form, making it difficult to diagnose these polypi from other morbid conditions, such as inversion and prolapse of the uterus and malignant growths.

Symptoms of Fibroid Polypi.—The most important are hæmorrhage and pain. The hæmorrhage, which is menorrhagic so long as the polypus is intra-uterine, becomes metrorrhagic after its extrusion into the vagina. The pain is caused chiefly, like the pain in labour, by the contractions of the body of the uterus, partly by the dilatation of the cervix and the os uteri, and by the pressure exerted on them by the protruding mass. The polypus itself is somewhat sensitive so long as it retains its envelope of mucous membrane. Pressure symptoms are rare. Deterioration of the general health follows from the frequently abundant and long-continued hæmorrhages, which cause profound anæmia, with its symptoms and dangers. A sloughing or suppurating polypus will give rise to the usual septic symptoms, and in cases of "enormous" polypi, like the one described above, death from exhaustion may occur.

The congestion and irritation caused by polypi are evidenced by leucorrhœal discharge, which is sometimes watery and profuse. It may become offensive from retention in the vagina and in cases where the growth is degenerate.

Women with large polypoid myomata are usually, but not always, sterile. If pregnancy occur the polypus may cause abortion, or possibly obstruction during parturition unless previously diagnosed and removed.

2. *Mucous polypi* usually grow from the mucous membrane of the cervical canal and protrude through the os uteri. More rarely they are found on the vaginal surface of the cervix. They consist of hypertrophied mucous membrane including some connective and muscular tissue. They usually retain the columnar ciliated epithelium of the endometrium with its glandular arrangement, but sometimes the epithelium shows a stratified structure. When these polypi are cystic they are known as "channelled polypi," when the connective tissue is dense the term "fibro-cystic polypus" is applied. Probably many cases of endometritis, polyposa, fungosa, and hæmorrhagica are really cases of multiple polypi (or pedunculated adenomata) of the endometrium; and just as these soft cervical polypi occasionally undergo malignant change, so the cognate condition of the endometrium may sometimes be precedent to one or more varieties of malignant disease of the body of the uterus. Localised hypertrophy of the cervical glands certainly constitutes adenoma cervicis benigna or maligna in different cases (see Williams on *Cancer of the Uterus*, London, 1888, pp. 40-44.

3. *Malignant polypi* (see pp. 197, 198, 226).

4. *Placental polypi* and *fibrinous polypi* may be considered together; for while in the former the fibrin of the blood is deposited on a shred of placenta or membrane, in the latter it is deposited on a ligature or suture left exposed after an operation such as hysterectomy. They are not neoplasms but accidents. The diagnosis is easy, the soft jelly-like clot, usually red, but sometimes decolorised, being unlike any ordinary growth. The foreign body which caused the coagulation being removed, the whole process comes to an end. The one symptom is hæmorrhage, moderate in amount and persistent in character.

In both cases the previous history of the case is likely to help to a correct diagnosis, the placental polypus occurring only after miscarriage or labour at term.

5. *Papillomatous polypi* are usually malignant. A papilloma of the cervix is rarely innocent; and even when apparently simple it demands removal with the portion of cervix from which it grows, as too often it recurs and eventually demonstrates its essentially malignant character.

6. *Tuberculous polypi* are rare and probably often escape diagnosis because their existence is not borne in mind.

Angiomata and *teleangiectatic tumours* are varieties of the fibro-myomata (see page 198).

ADENO-MYOMATA

This is believed to be a rare form of "fibroid," but until all tumours removed by operation, or post-mortem, are carefully examined by the microscope as well as by the naked eye, it is not possible to know anything definite about their histology, and many cases of adeno-myomata may pass unrecognised.

The glandular structures found in "fibroids" are derived from (*a*) in-growths of the glands of the uterine mucosa; (*b*) remains of the Wolffian body.

When the glandular elements of a fibro-myoma are derived from the glands of the mucosa the tumour is more or less central, abutting on the cavity of the uterus.

When the glandular elements are derived from remains of the Wolffian body the tumour is situated near a uterine cornu, or at any rate peripherally. Similar tumours are occasionally found in the Fallopian tube.

The fibrous, muscular, and glandular elements coexist in varying proportions in individual tumours. When the glandular element predominates the tumour may be very soft, full of cysts, and sometimes teleangiectatic or angiomatous.

The chief interest of these adeno-myomata uteri lies in their obviously probable connection with carcinomatous degeneration of "fibroids," rare though that degeneration is. Such a degeneration has been discussed by Kelly, Senn, Macnaughton Jones, Hektoen and Riessman, and other authorities. The whole subject wants much careful pathological research.

Kelly, in his *Operative Gynæcology*, vol. ii. p. 385, under the heading "Adeno-myoma uteri diffusum benignum," says, "In the Johns Hopkins Hospital *Reports*, vol. vi. p. 133, Dr. T. S. Cullen describes one of my cases constituting a new variety of myoma, under the name of 'Adeno-myoma uteri diffusum benignum.' I have also had two more cases during the past year. These adeno-myomata are rather more interesting from the pathological than from the clinical standpoint, because their true character cannot be recognised before operation, as their symptoms do not differ from those of simple myomata."

Hektoen and Riessman, in their *Text-Book of Pathology*, vol. ii. p. 1040, say, "Adeno-myomata are a rare form of myomata of the uterus containing gland-elements. The epithelial canals in these tumours are either derived from the uterine mucosa or the remains of the Wolffian body," etc.

In Stanmore Bishop's *Uterine Fibro-Myomata*, p. 95, we find the following: "In certain cases very distinct epithelial relics are found in myomata. These seem to represent remains of the primitive epithelium of Müller's duct. Relics of the Wolffian duct are found in the uterine wall. . . . Max Voigt has detected distinct glandular structures in two myomata. Hauser and Diesterweg trace these glands to Müller's duct, Nagel and Breus to the duct of the Wolffian body." These remarks explain how a fibroid sometimes becomes cancerous, a change which they believe occurs.

"Von Recklinghausen, following von Babes, who in 1882 detected true epithelial growths in the interior of uterine myomata, traces these growths, tubular or glandular bodies lined with epithelium, to the Wolffian duct. Coblenz insisted on the pathological importance of the uterine portion of that duct," *et seq.*

Differential Diagnosis of Uterine Fibroids

May be considered under two heads:—

1. While the tumour is still of moderate size and contained in the pelvic cavity it may be confounded with—

(*a*) Early normal pregnancy.
(*b*) Molar pregnancy.
(*c*) Extra-uterine pregnancy.
(*d*) Threatened or incomplete abortion.
(*e*) Subinvolution after parturition.
(*f*) Retroverted uterus, gravid or not gravid.
(*g*) Retroflected uterus, gravid or not gravid.
(*h*) Prolapsed, enlarged, or adherent ovaries and tubes.
(*i*) Small cyst, deep in broad ligament.
(*j*) Inverted uterus (mistaken for polypoid fibroid).
(*k*) Uterus infected with echinococcus.
(*l*) Malignant disease of the body of the uterus.

2. When the tumour is wholly or in part abdominal it may be confounded with—

(*a*) Pregnancy, from end of fourth month to term.
(*b*) Extra-uterine abdominal pregnancy.
(*c*) Ovarian tumours, cystic and solid.
(*d*) Broad ligament tumours.
(*e*) Hæmatocele.
(*f*) Perimetritis and parametritis.
(*g*) Splenic, hepatic, and renal tumours.
(*h*) Retro-peritoneal growths (chiefly sarcomata and lipomata).
(*i*) Distended bladder.
(*j*) Sarcomata of uterus.
(*k*) Hydatid cysts.
(*l*) Tumours formed by intestines and omentum matted together, usually by tuberculous disease.

Some of the above conditions admit of the very easiest elimination, others can be diagnosed with ordinary care, but others may defy the most painstaking examination and the closest reasoning.

In all cases where the diagnosis lies between a uterine pregnancy (the fœtus being alive) and a fibroid, time is an important factor; the question will be settled by the rate of growth and by the gradual development of the "certain signs of pregnancy." Discharge of blood, intermittent or persistent, during the early months may cause doubt, but either the case ends in miscarriage, or the steady growth in due relation to time, the detection of the fœtal heart sounds and movements, the procuring of ballottement, and the alternate contraction and relaxation of the tumour will shortly settle the question. On the other hand, amenorrhœa, instead of hæmorrhage, may accompany the existence of a fibroid, but its slower growth and the absence of the certain signs of pregnancy will afford grounds for a correct diagnosis.

The difficulty is greater when the embryo has perished and is retained in utero; but where there are no signs of life we may, after judicious delay, dilate the cervix and explore the uterus under anæsthesia.

The maximum difficulty in the differential diagnosis of fibroids and pregnancy is when they coexist. Here, again, time is the great elucidator, for owing to the usually accelerated increase in size of fibroids during pregnancy the uterus will soon be larger than is normal for the supposed time of gestation, and careful palpation will probably reveal one large boss or several bosses that are manifestly not parts of the fœtus.

In molar pregnancy, in abortion, and in subinvolution, where any doubt as to the accuracy of the diagnosis exists, the dilatation and exploration which are indicated as treatment will also reveal the true condition; which, however, would not be of immediate importance unless hæmorrhage or some other urgent symptom were present.

Swellings in Douglas' pouch may call for immediate recognition and treatment, as in the case of extra-uterine pregnancy; of retroverted or retroflexed uterus, especially if gravid; of prolapsed and enlarged ovaries and tubes; of an incarcerated fibroid. The history of the incarcerated fibroid would probably be longer than that of the various conditions of pregnancy. It would usually include attacks of hæmorrhage, while it would not be accompanied by mammary signs. The detection of the position of the uterus and the direction of its canal would be evidence for or against the tumour being the uterus itself, a fibroid, or some disease or displacement of the adnexa. The investigation may not be entirely free from risk, but non-recognition and consequent inadequate treatment of some of these confusing conditions may lead to a fatal result.

A fibroid polypus has been mistaken for a chronically inverted uterus. The diagnosis may be made on bimanual, or combined rectal and vesical, examination; the body of the uterus being thus detected in its normal position apart from the procident mass. The sound can be passed into the cavity of the uterus and all round the stalk of the polypus, unless the body of the polypus be adherent to the uterus, which is not common. Lastly, the polypus is comparatively or quite insensitive, which is not the case with the inverted uterus.

A prolapsed uterus is recognised at once by the position of the os uteri, into which the sound or a probe may be passed.

The uterus infested by echinococci presents some resemblance to the fibroid-bearing uterus, especially while the cysts are covered with uterine muscle and protrude as rounded bosses into the uterine cavity. The history and symptoms would probably help little, and the diagnosis would rest chiefly on the extrusion of one or more cysts and on the nature of the discharge should they burst *in situ.*

A cyst, whether parovarian or parasitic, deeply situated between the layers of the broad ligament may be so immovable and so tense as to greatly resemble a fibroid growing in the same position. In neither case is hæmorrhage a symptom unless other diseases, such as uterine fibroids or endometritis, coexist. In both conditions pain and pressure symptoms may be present, and generally the recognition of a "tumour in the broad ligament" has to be the provisional diagnosis until growth, or the supervention of serious symptoms, at once proclaims the nature of the trouble and demands operative assistance.

When the tumour is wholly or in part abdominal it should be easy to diagnose it from an uncomplicated pregnancy of the same volume, but it will frequently be impossible to assert or to deny the coexistence of fibroid disease with a comparatively early pregnancy. Some change in symptoms may occur, especially in the arrest of hæmorrhage if it existed before the pregnancy began. Mammary signs and softening of the cervix may exist in fibroid disease apart from pregnancy, and are in no case certain signs of gestation. Frequently the diagnosis cannot be certain until the mid-term of pregnancy brings the certain signs, or unless one or more fibroids can be felt per vaginam or per abdomen, and recognised apart from the enlarged, softened, and manifestly pregnant uterus.

Extra-uterine pregnancy, when advanced, will be easily distinguished from fibroids if the embryo is still alive, but difficulty arises when the child has perished and involution changes have occurred, or when extra-uterine pregnancy coexists with fibroids of the uterus. The symptoms of pregnancy may be much overshadowed by those of the fibroid. Hæmorrhage from the uterus may occur, while pressure symptoms and distress from increasing size would be aggravated by the coexisting pregnancy. If the history is well known and trustworthy it will be of great assistance, and probably the symptoms would demand interference for the removal of one or both conditions.

Ovarian and broad ligament cysts might be supposed to be easily diagnosed from fibroids, but in some cases the smooth, soft myoma greatly resembles an ovarian cyst on palpation, often yielding a sense of fluctuation, while the great test of passing the sound frequently fails to correct these faulty observations. It is assumed that the uterine cavity is elongated in cases of fibroid enlargement, and that, as it is unaltered in cases of ovarian cyst, the passing of the sound will give a diagnostic result. Unfortunately the distortion of the canal in many cases of fibroids, and its absolute blocking by submucous growths or adhesions in others, may completely prevent the passage of the sound and falsify the conclusions obtained. The duration of history should assist the diagnosis, but patients, even when honest, are often unobservant and inaccurate, and will give one year's history for a tumour that has obviously been growing five or more years. Lastly, abnormal hæmorrhage, although regarded as typical in cases of fibroids, does not always occur when they are present, whereas it may be present in ovarian cysts, especially in cases of dermoid cysts, and if tubal disease or endometritis coexist. Here again time is the great elucidator. Having found the tumour, its rate of growth can be observed, and should this be rapid, operation may be forced on the surgeon whether the tumour may be ovarian or uterine.

The solid tumours of the ovary are much less common than the cystic, and also less common than uterine fibroids. They can sometimes be diagnosed by their position, or by their manifest separation from the uterus, but these tests are not infallible. Inasmuch as solid ovarian tumours are seldom innocent an immediate diagnosis is necessary, and must be made even by exploratory incision if necessary.

Hæmatocele when recent is easy of diagnosis from fibroids, but sometimes in an old case where the blood has coagulated and a firm tumour results the distinction is difficult.

Splenic, hepatic, and renal tumours, if seen before the abdomen is filled by the growth, should be easily distinguished from fibroids of the uterus which grow from below upwards. The cases threatening confusion are rare, but their possible existence must be remembered.

Retro-peritoneal growths, chiefly sarcomatous, may usually be recognised by their comparatively rapid growth, by the unaltered length of the uterine cavity, by the absence of hæmorrhage, and by the immobility of the tumour. Sometimes these criteria fail, as when a fibroid is undergoing destructive changes or sarcomatous degeneration, and therefore increases rapidly in size, at the same time becoming less mobile. In these cases an exploratory incision may be the only means of diagnosis, and is certainly advisable when there is a doubt, for where the growth proves to be removable the exploratory incision is the first step of the major operation. On the other hand, should the growth be unfit for operation no great danger will be incurred as a result of exploration, provided strict asepsis is preserved.

Sarcomata of the uterus may well be mistaken for fibroids. The question often is whether any given tumour was a sarcoma from the first, or whether the malignant growth has supervened in a pre-existing fibroid. The practical question here is less of diagnosis than of treatment.

Distended bladder so frequently occurs in abdominal tumours that a catheter should be passed as a routine practice in all cases before operation, and even before an opinion is expressed.

Hydatids of the abdomen would appear more likely to be confused with cystic than with solid tumours, but occasionally they are found to fill the abdomen with a mass of hard round bosses yielding no general fluctuation, and closely simulating a multinodular fibroid. Unfortunately, as in other cases, neither the history nor the symptoms avail much. Both conditions are alike compatible with apparently perfect health, and in both the supervention of suppuration and other changes may bring the patient to death's door.

Perimetritis, parametritis, and localised effusions into the peritoneum can seldom be mistaken for fibroids. The upper rounded margin may closely simulate a tumour of the broad ligament, or of the space between the bladder and the uterus. On the other hand, the lower part of a fibroid, even when incarcerated in the pelvis, will seldom show so uniform a surface as occurs in para- and perimetritis; and the position of the uterus pushed up or to one side by a fibroid is seldom like its quasi-central position when it is embedded in an outpouring of plastic inflammatory products. The history, too, is widely different—cellulitis usually follows parturition, operation, or infection, and is accompanied by a rise of temperature and pulse, and by a general systemic reaction.

The difficulty is greater in old cases of cellulitis where shrinking and partial absorption have occurred, sometimes leaving an isolated hard mass in a broad ligament. Here the best clue is afforded by the less rounded outline and less sharp definition of the inflammatory mass, and also by the absence of any pedicle such as might be made out in a pedicled fibroid, though the pedicle might be simulated by strands of old inflammatory tissue between the intra-ligamentous mass and the uterus.

TREATMENT OF FIBROIDS

In some cases the treatment is to "let it alone"; but considering the many complications, degenerations, and dangers that may occur, the patient should be carefully examined at suitable intervals, and accurate notes kept of all the details of her case, so that rapid growth, attacks of pain, and other warnings of danger may receive attention.

Medical Treatment.—Medical treatment of fibroids has been almost entirely limited to efforts to control hæmorrhage and to relieve pain.

The drug most in use is ergot in one of its forms, administered either subcutaneously or by the mouth. Subcutaneously—sclerotinic acid or ergotinin; by the mouth—ergole or ergot in doses of 1 to 3 grains three times a day for three months, with possibly large doses of the liquid extract of ergot (one-half to one drachm combined with ten grains of bromide of potassium) during the periods if the hæmorrhage and pain are excessive.

Another drug used somewhat largely in America and also in Europe is hydrastis canadensis. This may be ordered in doses of $\frac{3}{8}$ gr. hydrastinine three times a day, or may be taken three times a day in doses of 20 to 30 of tincture of hydrastis.

Hazeline has been found useful, especially in cases where the hæmorrhage is caused by passive congestion of the uterine mucous membrane. It should be given in doses of 20 to 40 or even 60 drops combined with 10 of tincture of nux vomica and an ounce of chloroform water three times a day. In pill it can be given as extract of hamamelis gr. j., ext. nux vomica $\frac{1}{3}$, and ext. gentian, or pil. rhei co. gr. j., three times a day. Preparations of thyroid gland and of the suprarenal capsule have also been tried. Adrenalin hydrochloride in 3 minim doses checks hæmorrhage, and calcium chloride is sometimes effectual.

It is to be borne in mind that these drugs are directed against one symptom only, and that even if they check the hæmorrhage they have no power to relieve pressure effects, to prevent degeneration, or to deal with complications. Ergot, the most powerful of the three, is scarcely a drug to be used for months and years. It is chiefly useful in cases of submucous fibroids or polypi, for by stimulating the muscular contractions it may assist in the extrusion of the mass.

The relief of pain is a difficult question. It is sometimes a very marked and exhausting symptom, and yet in a disease which may run a very chronic course it is wrong to teach the patient the morphia habit, or to permit her to depend on any drug in the long list of analgesics and hypnotics.

Electrolysis as applied to fibroids has been long known and has been largely used, especially by Apostoli and his school in France, and in Great Britain by Dr. Keith and his sons. When the mortality of direct operations on the tumour or the uterus was heavy, electrolysis was gladly hailed, and it had a fair and prolonged trial.

It has greatly disappointed the hopes of both surgeons and patients, and is now but little used in England. It is a tedious, painful, and very uncertain remedy. It is not free from danger, especially if the sharp electrode is plunged into the tumour or into the musculature of the uterus. It is so used with the intention of producing a limited and aseptic necrosis of the part of the tumour into which it is plunged, but the process may be neither limited nor aseptic, and sometimes leads to destructive changes which may entail prolonged invalidism or even septicæmia. When the blunt electrode only is used the effects of the electrolysis is confined to the mucous membrane, and in cases where there is hæmorrhagic endometritis some improvement may be obtained.

Surgical treatment includes operations applicable to all the varieties of fibroids. To begin with the simplest operations on fibroid polypi—when of moderate size and extruded into the vagina these may be easily removed by avulsion or torsion of the pedicle. If the pedicle is thick, it is well to circumcise the mucous membrane and then to twist the fibrous pedicle remaining. This little operation, like all others, should be done with full aseptic care. In large or "enormous" polypi, where the pedicle cannot be reached, the bulk of the tumour should be reduced by morcellation, using strong toothed forceps and scissors curved on the flat, until finally the stalk is reached. In cases in which the polypus is not yet extruded it may be necessary to dilate the cervix uteri, or to make bilateral incisions in it so as to bring the lower pole of the polypus within reach. In no case should the ecraseur be used, as it has a tendency during tightening the wire loops to grasp a portion of the uterine wall, which would thus be seriously injured.

Enucleation of Submucous Fibroids.—This operation has a very limited range, and is never advisable unless the tumour is apparently single, and so projects into the uterine cavity as to make its enucleation at one sitting a probable result. We have properly abandoned the dangerous practice of incising the mucous membrane and the capsule, and then waiting for the uterus to expel the tumour, assisted when necessary by traction and drugs. This method causes the devitalisation of the tumour, and often leads to suppuration within the capsule, and to sloughing of the tumour which may extend to the surrounding tissues. In these cases the products of decomposition are carried by the uterine lymphatics into the general circulation and septic infection is the result. The operation is so uncertain and so dangerous that even were the mortality of hysterectomy and myomectomy double what they are it would still be condemned.

Morcellation of fibroids and their removal per vaginam has long been practised in America, but it has been chiefly brought before the profession by Péan and his pupils. He thought it a suitable operation for the removal of even the largest tumours, but it frequently fails in such cases and then total hysterectomy has to be performed by a tired surgeon on an exhausted patient. Morcellation should be limited to cases in which the tumour is wholly uterine and does not extend into the broad ligaments; where the total mass does not exceed that of a five months' gestation; where the vagina is wide enough to permit of the necessary manipulations; and, finally, where the tumour is healthy.

Method.—The patient lies in the lithotomy position. After thorough cleansing of the vulva and vagina Auvard's speculum is introduced and the uterus lowered by pressure from above and, if necessary, by seizing one or both lips with forceps whose grip depends on apposition and not on teeth. The cervix is then freed from its vaginal attachments and incised up to the lower pole of the tumour, so as to make two lips up to its level. Two pairs of Museux toothed forceps are then fixed on the tumour, and with scissors curved on the flat, or with a bistoury curved on the flat, the mass of tissue commanded by the lower forceps is removed. The forceps are reapplied higher on the tumour and the process repeated as often as is necessary. A finger in the uterus and the other hand on the abdomen give information as to progress, and warning as to possible opening through into the peritoneal cavity. Sometimes the upper part of the tumour may be shelled out with little difficulty—a large, ragged, and sometimes bleeding cavity is left; hæmorrhage must be arrested by the application of long pressure forceps, and both it and sepsis prevented by irrigation with 2 per cent carbolic lotion or iodine water, or a solution of formalin, 1 per cent, at a temperature of 110° to 120° F. Gauze soaked in 5 per cent solution of adrenalin chloride is extremely effectual in stopping hæmorrhage. The cavity is then packed with strips of iodoform gauze. Shock, if present, is met with the usual remedies and the patient put to bed. This method appears to work well if the limits as to size and condition of the tumour are observed. It has the advantage of leaving a functionally useful uterus; but it must fail in the following cases: when there are many separate fibroids scattered throughout the uterus, when they invade the broad ligaments, when the size of the tumour is excessive, and, above all, when suppuration, necrosis, sloughing, or other destructive changes have occurred. The risk of sepsis is then very great.

Vaginal hysterectomy, described under "UTERUS, MALIGNANT TUMOURS," at p. 230, is of service in tumours that are not too large to admit of extraction of uterus and tumour through the vagina. It is the operation of election in multiple fibroids of the uterus, exclusive of the subperitoneal variety, when the size is not excessive, when the broad ligaments are not invaded, when the tumours, so far as can be ascertained, are healthy, and when there is no known pelvic complications of an inflammatory or septic nature.

The process of morcellation as described above can be combined with the classical operation of vaginal hysterectomy, and the uterus so reduced in bulk can be removed, leaving behind no ragged cavity to start a septic infection.

Colpotomy, or incision through the vaginal roof, in order to reach and remove "fibroids" has a very limited range, it can only be useful in cases of subserous growths, and comes into competition with vaginal hysterectomy on the one hand and with operations per abdomen on the other. It also has the disadvantage of affording imperfect demonstration of, and access to, coexisting disease such as pyosalpinx.

ABDOMINAL OPERATIONS FOR FIBROIDS

1. *Abdominal hysterectomy* (see p. 229).

2. *Abdominal myomectomy*, the removal of the fibroids alone through an abdominal incision. This is the operation of election in cases where there is one tumour or a few tumours too large for removal per vaginam, where the growth is intra-ligamentous, and where it is subperitoneal. It is unsuitable where there are many small growths, and where they are submucous.

The abdomen being opened if the tumours are subperitoneal, the peritoneum over the growths is incised, the tumour shelled out, the flaps trimmed, and hæmorrhage having been arrested they are sewn together with Lembert's suture.

If the growth be a solitary soft myo-fibroma embedded in the hypertrophied musculature of the uterus, the operation is more difficult, but it is well worth doing in suitable cases. The uterine tissue is incised down to the tumour, which is shelled out by the fingers, aided by scissors or scalpel if necessary. Hæmorrhage, which would otherwise be formidable, is controlled by an assistant grasping the chief vessels through the broad ligaments. The raw cavity is obliterated and permanent hæmostasis is secured by superimposed layers of sutures, and, lastly, the peritoneal flaps are united by a Lembert's suture. The chief anxiety is so to unite the tissues and to obliterate the cavity as to prevent the formation of a hæmatoma, which would probably prove very troublesome. Where this operation is successful the uterus and its appendages are left in a functionally perfect state, and in careful hands its mortality does not exceed that of abdominal hysterectomy.

3. *Removal of the uterine appendages.*—This operation was devised by Lawson Tait, and was gladly welcomed by the profession at a time when the alternative was the clumsy and dangerous hysterectomy with the stump of the uterus clamped in the lower angle of the abdominal wound. Now that an improved technique has reduced the average mortality of abdominal hysterectomy to 10 or even 5 per cent, Tait's operation has fallen into disuse. Tait himself in his latter days admitted that it was useless in the soft, solitary fibroid; its effects, even when it checks hæmorrhage, are too slow in cases where pressure symptoms call for relief; and at the present time surgeons are anxious to spare one or both ovaries in order to save the patient the distressing symptoms of a premature menopause.

Ligation of the uterine arteries (per abdomen and per vaginam) has been suggested with the intention of lessening the blood-supply to the uterus and so starving its tumours. The operation may be easy, difficult, or impossible, according to the size and position of the fibroids. The most serious objection to it is the uncertainty of the results. It may do too much or too little. In some cases the collateral circulation develops so well that the tumour flourishes undisturbed, in other cases its vitality is so lowered that it is liable to degenerate. In no case can the ultimate result be known before operation, nor indeed for some time after.

Tuberculosis of the Uterus

1. Occurs as an extension of tuberculous disease from the Fallopian tubes.

2. As an infection from the vagina.

3. As part of a general tuberculosis.

(1) When it occurs as an extension from the Fallopian tubes the sequence appears to be first tuberculous disease of the intestine—the mucous membrane, muscular and peritoneal coats, suffering in succession. Infection of the general peritoneum follows. Thus the bacilli obtain access to the Fallopian tubes and through them to the uterus. In these cases the fundus and corpus are earliest and chiefly involved.

(2) In infection from the vagina the morbid process occurs in the cervix, and may be limited to it.

(3) In general tuberculosis the uterus is said to be invaded in about 66 per cent of the cases. Tuberculosis of the uterus has been recognised in four forms, of which three appear to be a sequence, or phases of one process: (*a*) miliary; (*b*) caseous; (*c*) fibroid, the usual life-history of tuberculous lesions; while (*d*) papillary tuberculosis seems to be a special development.

In the earliest stage of uterine tuberculosis the epithelium is intact and the glands normal, the tubercle being found in isolated specks scattered in the subjacent tissues where the network of vessels surrounds the extremities of the glands.

In a more advanced stage the uterine cavity is covered with a more or less necrotic caseous material, and below this there is tubercular tissue involving the superficial layer of the musculature and in which the typical bacilli and giant-cell formations may be found. At this stage there are sometimes multiple shallow ulcers with undermined edges in the mucous membrane. In the papillary form a definite growth occurs, usually in the cervix, growing from the mucous membrane of the arbor vitæ. It pushes aside the pavement epithelium of the portio vaginalis, attains a considerable size, and to the naked eye resembles epithelioma of the cervix, for which no doubt it is frequently mistaken.

The symptoms of uterine tuberculosis are not pathognomonic. Menorrhagia, metrorrhagia, and discharge occur as in many other diseases, and pain is not common unless there are coexisting tubal and ovarian lesions with inflammatory adhesions.

Treatment.—The symptoms are likely to lead to curetting, and the possibility of the existence of uterine tubercle should insure microscopic examination of the scrapings. In cases where other treatment fails removal of the involved organs is indicated.

HYDATIDS OF THE UTERUS.—These parasites probably gain admission by penetrating the uterine tissues from the abdomen or neighbouring organs. They may be found under the peritoneum, in the walls, or under the mucous membrane. They can easily pierce the peritoneum and develop fresh colonies in the pelvic or abdominal cavities; or, piercing the mucous membrane, they may be extruded into the cavity of the uterus and so escape per vaginam.

The symptoms vary with the position of the mass. If the cysts are large and develop towards the abdominal cavity, a smooth, elastic swelling may be felt through the anterior abdominal wall. This tumour must be diagnosed from ovarian and broad ligament cysts, from fibroids and from pregnancy. Pain may arise from pressure and from inflammation, the patient may also suffer from a sense of weight and uneasiness. Difficulties of micturition and of defæcation may occur, and the periods are often irregular. Where the tumour communicates with the uterine cavity there may be expulsion of variously sized cysts also of fluid and of blood. The hæmorrhage is seldom severe; it usually occurs as a slight but persistent metrorrhagia. In some cases sympathetic mammary changes occur which complete the simulation of ordinary pregnancy, or of pregnancy with hydatidiform degeneration of the chorion. A certain diagnosis rests on the detection of hooklets and on the chemical characters of the fluid discharged. It contains no albumin and therefore is not coagulated by the ordinary reagents, such as heat and nitric acid. It does contain chloride of sodium and therefore becomes turbid on the addition of nitrate of silver. The diagnosis is specially important in the case of large masses simulating fibroids, ovarian, and other cysts, because the entrance into the abdominal cavity of the hooklets and minute cysts must be carefully avoided.

Treatment.—When hydatids of the uterus simulate a vesicular mole, the cervix should be dilated and the uterus evacuated and curetted. If the tumour present unbroken at or near the os uteri, it should be incised, its contents cleared out, then it should be irrigated with 25 per cent solution of hydrogen peroxide, and, lastly, it should be packed with long strips of iodoform gauze. In the case where hydatids have burrowed deeply into the musculature of the uterus, hysterectomy may be needed.

ACTINOMYCOSIS OF THE UTERUS is very rare, and when it exists is probably only an extension from the Fallopian tubes. Even in these actinomycosis is said to be "an anatomical curiosity" (see vol. i. p. 70).

V. Malignant Tumours of the Uterus.

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The term malignant when used in relation to a tumour signifies that it inevitably destroys life; and in the article "Tumours" (vol. xii. pp. 440-458) every care is taken to point out that malignant tumours occur in the connective tissue group, where they are called sarcomata, and in the epithelial group, where they are known as cancers or carcinomata. As the architecture of the uterus is such as to render it liable to carcinomata and sarcomata, it will be useful to briefly review the distribution of the connective tissue and the epithelial elements in this complex organ, and also to consider certain structures connected with the development of the embryo, which have acquired notoriety in relation to some destructive tumours of a peculiar type.

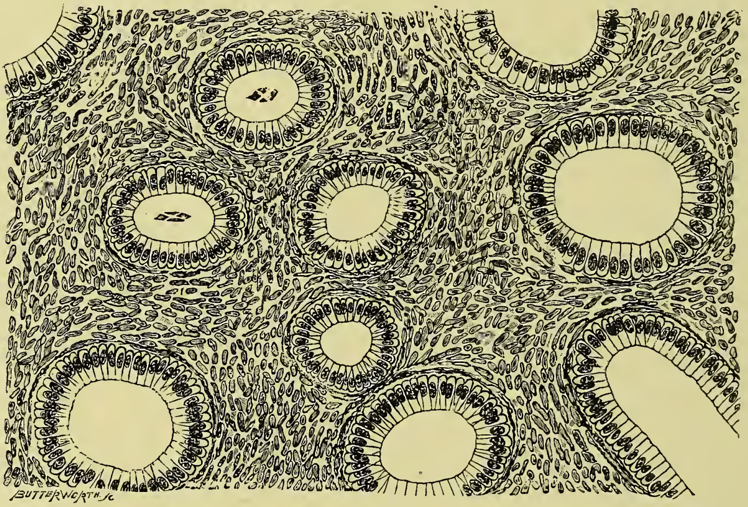

Fig. 1.—The tubular glands of the uterus in section. Magnified. (From the writer's book on *Tumours*.)

The uterus is structurally a hollow muscle of the unstriped variety, containing, as is usual with this kind of muscle, a central space lined with mucous membrane. In this instance the mucous membrane is called the endometrium, and presents such peculiar characters that it may, without exaggeration, be described as the most extraordinary mucous membrane in the body. If the Fallopian tube or a piece of small intestine be examined in transverse section, it is quite easy to distinguish its muscular coat and to separate it from the mucous membrane, a loose connective tissue track indicating the boundary line. In the uterus there is no such line of separation, and the walls are thick and resistant. A careful study of the morphology of the uterus, however, teaches that this thick wall represents an enormously developed muscularis mucosæ, and this metamorphosed area extends from the fundus to the vaginal opening (external os) of the uterus. The endometrium which lines the cavity of the uterus is distinguished from that belonging to the cervical canal by the fact that when the Fallopian tube, the uterus, or an ovarian follicle contains an oösperm (fertilised ovum), the superficial parts of the endometrium above the point known as the internal os become changed into a thick, soft membrane known as the decidua, which is sometimes shed as a membranous bag, or in shreds when pregnancy fails.

The epithelium in relation with the uterus exhibits some remarkable variations which need consideration. The endometrium of the cavity of the uterus is beset with a single layer of columnar ciliated epithelium directly continuous with that lining the Fallopian tubes. This epithelium dips into the endometrium very deeply, and forms long tubular glands; they run obliquely in the mucous membrane, and sometimes bifurcate at the extremity (Fig. 1).

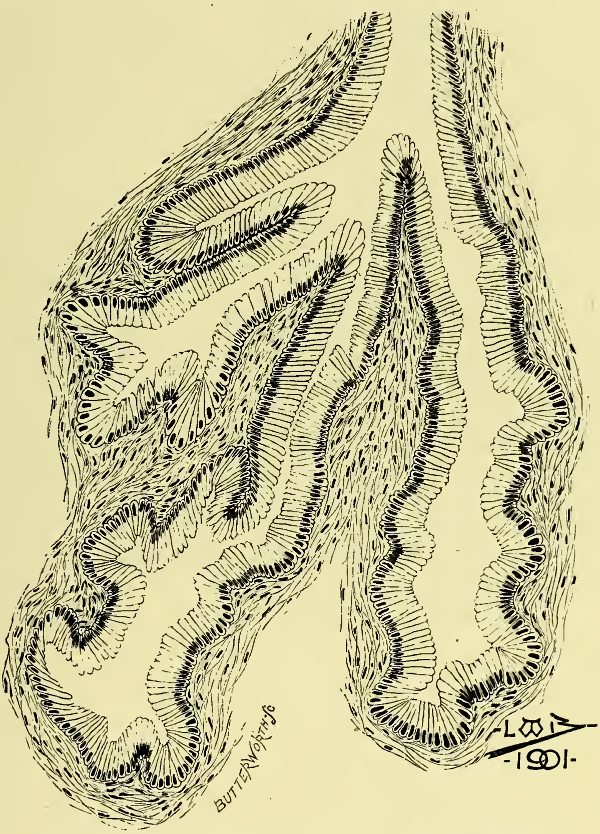

Fig. 2.—A gland from the cervical endometrium (magnified).

The glands which belong to the cervical endometrium are of the racemose kind, and possess cylindrical epithelium which differs from that belonging to the glands in the body of the uterus in that the cells are narrower (Fig. 2). The stroma in which the glands are embedded is denser than that in the body of the uterus, and the cells are spindle formed. At the external orifice of the uterus the epithelium undergoes a sudden change, and instead of consisting of a single layer the surface cells stratify, and the whole of the cone-shaped portion of the cervix uteri which projects into the vagina is covered by squamous epithelium, directly continuous with and like that clothing the wall of the vagina (Fig. 3). In the normal uterus the transition from the single cell layer of the cervical endometrium to the multiple cell strata of the vaginal surface of the cervix occurs very abruptly at the margin of the external orifice of the uterus. It is necessary to be familiar with these cell modifications, because the epithelial elements of cancers of the uterus are determined according to the part of the organ in which they arise.

The distribution, microscopic characters, and peculiarities of uterine cancer are determined by epithelium. When describing the features of cancer in general (vol. xii. p. 458) it was pointed out that this disease exhibits peculiarities in its mode of growth, infection of lymph glands, dissemination, and the way in which it destroys life according to the organ in which it arises. These features are illustrated in an extraordinary way in the uterus, for the frequency, course of the disease, clinical characters, and the way death is induced, vary widely according to whether the cancer arises in the epithelium of the cervix or in the body of the uterus. So that on pathological as well as on clinical grounds it is convenient to consider the subject in two sections, viz. cancer of the neck of the uterus, and cancer arising in the endometrium of the body of the uterus.

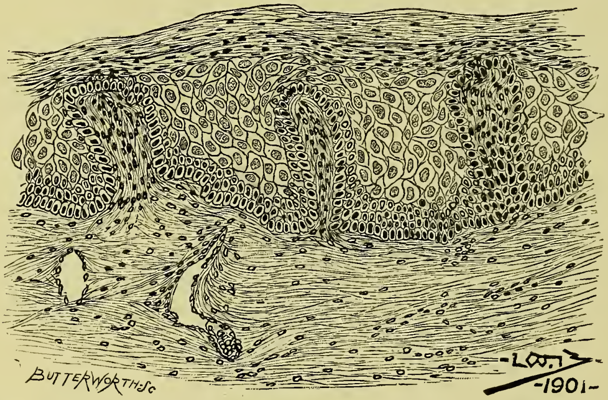

Fig. 3.—The microscopic characters and disposition of the epithelium on the vaginal aspect of the neck of the uterus.

Cancer of the Neck of the Uterus.—Careful statistical inquiry shows that the three organs most liable to cancer are the mamma (breast), the neck of the uterus, and the stomach. The same method of investigation also brings to light the important fact, that cancer of the neck of the uterus is almost exclusively confined to women who have been pregnant. The writer found in one hundred consecutive cases of undoubted cancer of the cervix that ninety-nine patients had had one or more children; and the exceptional patient was a married woman, and in her case a miscarriage could not certainly be excluded. This disease is very common between the fortieth and the fiftieth years; many cases occur between the thirtieth and the fortieth years. Before the thirtieth year the disease is rare, but the writer has observed undoubted cases in women of twenty-three, twenty-five, and twenty-six years. Cancer of the neck of the uterus belongs especially to the latter part of the child-bearing period of life and the decade subsequent to the menopause. It is not easy to determine whether this predisposition depends on injury to the cervix due to delivery, or to traumatism associated with coitus. A remarkable observation bearing on this matter has been made by Czerwenka. A woman, thirty-five years of age, had a double vagina and "uterus bicornis bicollis." Coitus was practised on the left vagina. Panhysterectomy was performed because of cancer of the left cervix; the left uterus contained two fibroids, and the corresponding Fallopian tube contained pus and had its cœlomic ostium occluded. The relation of pregnancy to cancer of the neck of the uterus is shown in the table on p. 221.

Cancer may begin at any part of the cervix from the internal orifice of the cervical canal to its junction with the vaginal wall. The character of the epithelium determines the microscopic features of the cancer. Thus when the disease begins on any part of the vaginal aspect of the cervix, the cancer is of the squamous-celled (epithelioma) species; but when it arises from the cervical endometrium its distinguishing epithelium is of the columnar type (Fig. 4).

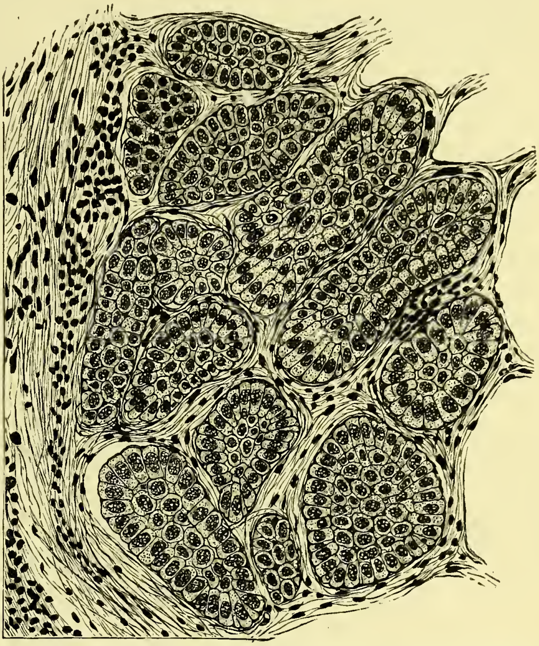

Fig. 4.—The microscopic characters of cancer beginning in the endometrium of the cervical canal. From the writer's book on *Diseases of Women*.

A great amount of careful labour has been expended on the microscopic examination of cancer of the neck of the uterus, with the hope of determining the relative frequency of squamous-celled and of glandular carcinoma. So far as the writer's efforts were concerned, his object was to decide if possible which species gave the best result to treatment. In a small proportion of cases, and especially those in the very early stages, it is a simple histologic exercise to determine the species, but unfortunately in the advanced cases it is not an easy, and certainly in some instances an impossible task to determine whether it be a squamous-celled or a gland-celled cancer. Some of the confusion in recent writings is due to the neglect of the fact, that when a cancer originating in the epithelium of the cervical endometrium overruns the vaginal surface of the cervix it assumes the squamous-celled or stratified arrangement. This mutation of epithelium may be studied in the case of cancer of the rectum; when the disease involves the outlet of the bowel, the anal portion often has the structure of squamous-celled cancer, whereas the epithelium of the primary rectal tumour retains its columnar character. With our present means of investigation it is hazardous to attempt a prediction simply on the cell features of the cancer.

Mutation of epithelium may also be studied in a uterine polypus. For example, a polypus arising in the endometrium will be clothed with mucous membrane, covered with a single layer of columnar epithelium, but when the tumour protrudes into the vagina, the epithelium of the portion resting on the vagina stratifies and resembles the epithelial covering of the vagina. In a small pedunculated polypus of the cervical endometrium it is an interesting task to cut sections through the whole length of tumour, and study the transition in the epithelium. This peculiar change in the epithelium has been erroneously described as squamous-celled cancer arising in a uterine polypus.

Although the ultimate results of cancer arising in the cervical endometrium or on the vaginal aspect of the cervix are the same, it will be advisable to discuss their pathologic features separately. It is necessary to mention that in the great majority of cases which come under observation, particularly in hospital practice, the disease has destroyed or eroded the neck of the uterus to such an extent that it is impossible to determine whether it arose in the cervical canal or in the epithelium of its vaginal aspect. Nevertheless, patients do occasionally come under observation at a sufficiently early stage to enable an exact localisation of the primary focus of the disease. In this way it has been determined that squamous-celled carcinoma of the cervix begins in much the same way as on the lips or tongue. It may appear as a circular ulcer with raised and averted edges, or it may erode the tissues deeply at the outset; exceptionally it forms luxurious warty excrescences. The growth quickly infiltrates the cervix (Fig. 5), extends to and implicates the vaginal wall, and then involves the connective tissue of the mesometrium (broad ligament).

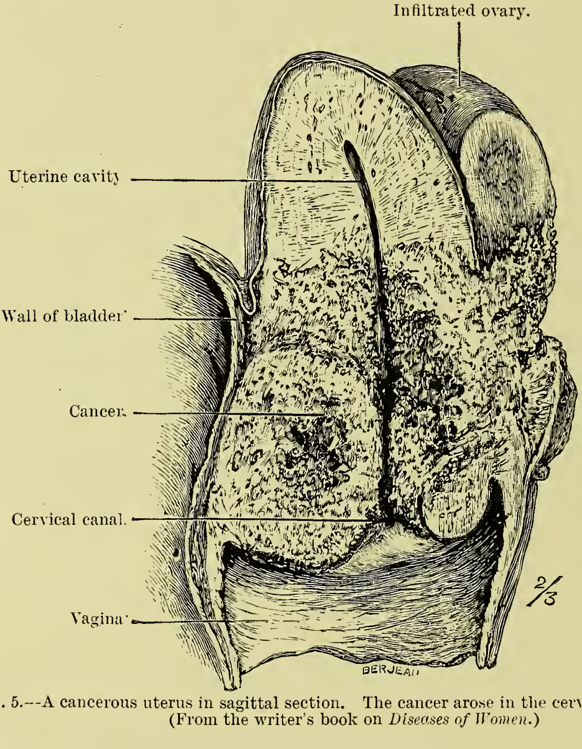

Fig. 5.—A cancerous uterus in sagittal section. The cancer arose in the cervical endometrium. (From the writer's book on *Diseases of Women*.)

Cancer arises in the epithelium in any part of the cervical canal or its glands, but it appears to be more prone to arise in the lower than in the upper half of the canal. It begins either as a deeply eroding ulcer, or as a soft, fungating, vascular, cauliflower-like outgrowth. Commonly the cancer spreads, and after infiltrating the adjacent tissues of the cervix spreads into the mesometrium, and implicates the vaginal wall. It ulcerates early and destroys the cervix, and spreads into the body of the uterus, and in the late stages this organ may become hollowed out by ulceration, until nothing but a thin layer of muscle tissue covered by peritoneum remains (Fig. 6).

The microscopic features of cancer arising in the cervical epithelium consists of rounded spaces filled with columnar epithelium. This is due to the fact that the invasion of the tissues is due to columns and cylinders of epithelium, and in the microscopic sections these cell columns are cut at right angles.

Cancer of the cervix leads to infection of the lumbar lymph glands. Dissemination is also frequent, and secondary deposits form in the lung, liver, and other organs; but deposits do not occur in the bones with the same frequency as in cancer of the mamma. The worst features of cancer of the neck of the uterus do not arise from dissemination, but are due to the slow and insidious way in which the growth implicates adjacent structures; and this demands attentive consideration, because it is this aspect of the disease which imposes very marked limitations to its surgical treatment.

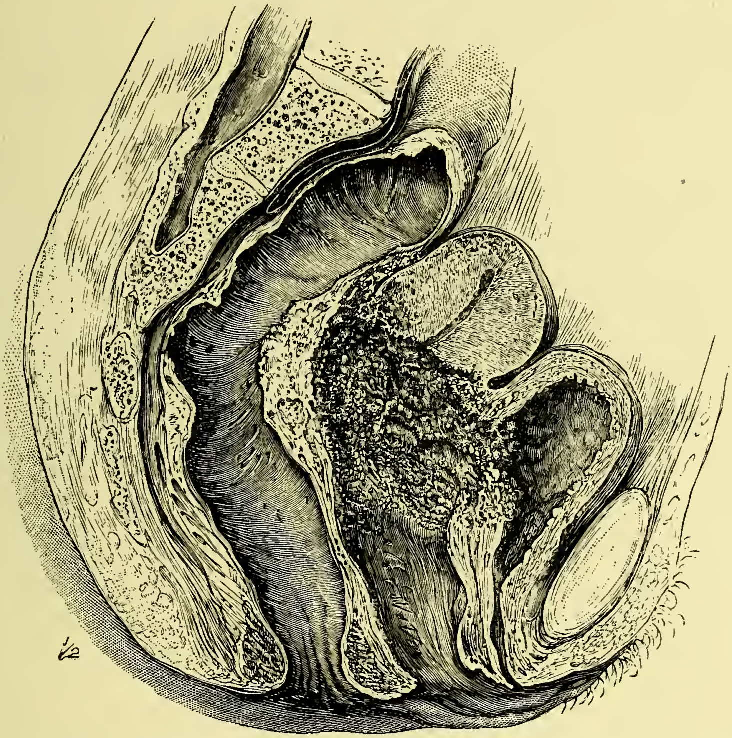

Fig. 6.—Pelvis and its viscera in section. From a case of cancer of the uterine cervix which invaded the bladder. (From the writer's book on *Tumours*.)

The neck of the uterus is in close relation in front with the bladder; posteriorly it is in contact with the rectum, and it has on each side of it a ureter. Another dangerous relation is the uterine artery which joins the cervix near the utero-vaginal junction. A careful study of the clinical facts connected with cancer of the neck of the uterus demonstrates that its more lethal character, considered apart from its frequency, as compared with cancer of the body of the uterus, is due to the secondary effects resulting from the implication particularly of the bladder, ureters, and uterine arteries (Fig. 7). The occurrence of the many serious complications of cancer of the cervix is mainly determined by the primary position of the lesion. For example, if the cancer begins on the posterior aspect of the vaginal surface it will, whilst it is deeply eroding the cervix, extend to the posterior vaginal wall, infiltrate the recto-vaginal septum, and either lead to a fæcal fistula or obstruct the bowel. On the other hand, it may start on the anterior surface and involve the vesico-vaginal wall, lead to cystitis, which may spread to the ureters and infect the renal pelvis, producing pyelitis, or in many instances render the patient extremely miserable by perforating the bladder, and producing a vesico-vaginal fistula.

When the disease begins in the cervical canal it exhibits a tendency, so marked in cancer of the intestine, to circumscribe the canal, and at the same time it infiltrates the tissues adjacent to the cervix, and in this way implicates the base of the bladder and one or both ureters. In such cases it is not uncommon to find that segment of the ureter which traverses the mesometrium converted into a solid column. The liability of the bladder and the ureters to be implicated in cancer of the cervix explains the frequency with which uræmic symptoms become manifest in the terminal phases of this disease.

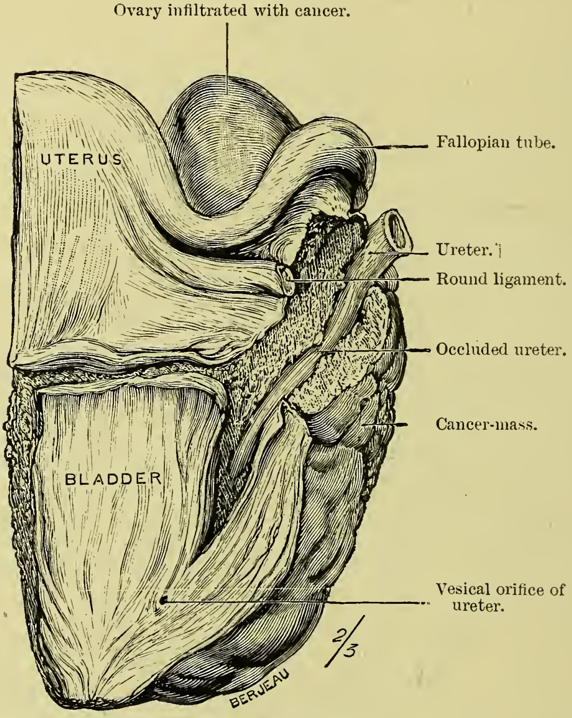

FIG. 7.—Cancer of the cervix uteri implicating the ureter and bladder. (From the writer's book on *Diseases of Women.*)

Cancer of the cervix tends to block the cervical canal, and in this way obstructs the free escape of the uterine secretion. The result is that the retained secretion becomes infected from the necrotic and decomposing tissue about the cervix, and becomes purulent and produces a condition known as pyometra. In some of the cases the cancerous tissue sloughs and allows the pent-up pus to escape, and irregular "gushes" of pus are not infrequent phenomena in the later stages of the disease. A pyometra becomes a source of danger when the infection extends to, and involves the Fallopian tubes. These structures then become thin-walled pus-sacs. Should the infective fluid contained in a sac of this kind leak into the belly through an unoccluded ostium, or should a perforation occur in the wall of the tube, death may follow in a few hours from septic peritonitis. Almost at any period in the course of the disease the uterine artery may be broached, and the patient suffers from severe and sudden bleeding. This in a certain proportion of cases terminates life, and when it falls short of this it places life in great jeopardy. Probably on the whole the patient's strength is more gradually exhausted by oft-repeated small bleedings, and thus death slowly supervenes, than that life is suddenly extinguished by a furious hæmorrhage of short duration. However, the two earliest, and the most constant signs of cancer of the neck of the uterus are frequent fitful losses of blood, and purulent and offensive discharges from the vagina. It is for one or other, and more frequently for both, of these signs that the patients seek advice, and in a small proportion of cases they also complain of pain.

It is the duty of every practitioner to examine carefully the uterus of women who complain of these troubles.

In the early stages the margin of the uterine orifice may be found hard and everted. Perhaps a soft mass protrudes from the canal and bleeds on the slightest touch. Occasionally a cauliflower-like mass will be found sprouting from the vaginal surface quite clear of margins of the "os." In some cases the conditions are such as to preclude a positive diagnosis, but bleeding, even on gentle manipulation, is always a suspicious sign, and especially when women complain that coitus is followed by slight bleeding. In cases of doubt an accurate diagnosis is of so great importance for the welfare of the patient, that a fragment of the suspected tissue should be removed and submitted to microscopic examination.

When the disease is well established its diagnosis is never difficult. The ulcerating, fungating, bleeding mass which protrudes from the cervical canal, or the crater-like depression which replaces it, with the hard, infiltrating ring of tissue which can be traced into the vaginal walls, are features easily recognised by the trained finger.

Cancer of the uterus terminates life in a variety of ways, which it will be useful to summarise:—

1. The uterine artery may be opened by ulceration, and fatal bleeding ensue.
2. Repeated bleeding from smaller arteries, and from the surface of the cancer, often leads to exhaustion and death.
3. Implication of the bladder, and of one or both ureters, causes cystitis, septic pyelitis, and uræmia.
4. Septic changes in the uterus extend to the Fallopian tubes, and septic matter may leak through an unoccluded ostium and establish peritonitis.
5. Peritonitis may follow rupture of a pus-containing Fallopian tube.
6. Intestinal obstruction may follow the adhesion of a piece of intestine to the uterus, or direct extension of the cancer into the rectum.
7. Hydroperitoneum and hydrothorax may arise from the presence of secondary nodules on the peritoneum or pleura.
8. Secondary deposits in the brain are rare, but they occasionally induce fatal coma, and sometimes attacks of acute mania.

The only treatment available for cancer of the neck of the uterus is that adopted for cancer in other parts of the body, namely, thorough removal at the earliest possible moment; but, unfortunately, it is only practicable to carry this out in a very small proportion of patients. The first object in a radical operation for the relief of cancer in any part of the body is a wide removal of the infected part, and this is prevented in the case of the cervix by the proximity of the bladder, ureters, and rectum. When the patient comes early under observation, and especially when the cancer is limited to the cervical canal, the performance of vaginal hysterectomy is followed by satisfactory consequences immediate and remote; but when the disease has overrun the cervix and implicates the vaginal wall, it is impossible to make a free removal of infected tissue without imperilling the integrity of the bladder and ureters, and thus anticipating some of the most distressing effects of the disease. Quite apart from the limitations which the anatomical environment imposes on surgical efforts in the treatment of this disease, there is, unfortunately, the insidious character of the disease itself, and only a small percentage of patients seek advice when there is an opportunity of doing good by surgery. In recent years the mortality of vaginal hysterectomy of cancer of the cervix has reached the low point of 5 per cent, but the frequency and rapidity of recurrence has discouraged many surgeons. Now that the profession is awakening to the necessity of early diagnosis in this dreadful disease, and at the same time realising that the only hopeful cases are those where the operation is undertaken in the early stages, and that surgeons abstain from operating except in the promising cases, so will the results improve, and patients will be encouraged to seek surgical aid at the very outset.

In the majority of cases where no radical operation is possible, much may be done to make the patient's life not only tolerable but even comfortable. In a very large proportion of cases the patients are able to keep about, look after their homes, and lead useful lives often for many months until renal complications and anæmia, the joint result of repeated bleeding and purulent discharge, so weaken them that they are compelled to keep abed. At this stage careful nursing renders them fairly comfortable: the patients should be kept scrupulously clean by daily douches of warm water tinged with permanganate of potash. When the discharge is offensive a daily douche of perchloride of mercury (1 in 5000) will rarely fail to correct it. Pain may be alleviated by the judicious use of morphia administered subcutaneously. The constipating effects of this drug are best met by variations in diet, accompanied by ripe fruit and vegetables, aided by occasional enemata consisting of two to four drachms of turpentine, an ounce of castor oil, a small piece of soap, and a pint of warm water.

In cases unsuitable for operation life is rarely prolonged beyond a year and a half. Many die within a few months from the time they come under observation.

In order to emphasise the small proportion of cases of cancer of the uterus in which a radical operation can be carried out with success, the writer had a list prepared of fifty consecutive patients admitted into the Chelsea Hospital for Women, London, for the purpose of operation. The plan usually followed is to admit such patients with cancer which the junior officers think may prove suitable (the advanced cases are not admitted into the institution). The patient is then examined under an anæsthetic to ascertain the extent of the disease, and especially to determine if the cancer is limited to the uterus. The large proportion of rejections, even in cases which seem favourable without this critical examination, is well shown in the subjoined table. It is very important to exercise a rigid selection of cases for operation, otherwise vaginal hysterectomy for cancer runs a great risk of being discredited. The table was drawn up by Dr. Crewdson Thomas, the registrar: the patients were admitted during 1897, 1898, 1899, and 1900. During these years the average number of women who were operated upon for diseases of the genital organs was 500 yearly. The lists show the frequency of the disease, and also demonstrate that cancer of the cervix has an extremely significant relation to childbirth.

So far as this table is concerned, and indeed in very large collections of cases, cancer of the cervix is seen to be intimately associated with the later period of sexual life and the decade following the menopause. It is almost unknown before the twenty-fifth year, the great proportion of cases falling in the zone between the thirtieth and fifty-fifth years of life.

Table of 50 *Consecutive Cases of Cancer of the Neck of the Uterus*

No.	Age.	Children.	Miscarriages.	Treatment.	Remarks.
1.	21	1	...	Vag. hysterectomy	
2.	27	1	...	Inoperable	
3.	29	1	...	,,	
4.	29	2	...	Vag. hysterectomy	
5.	30	1	1	Inoperable	
6.	31	...	1	Vag. hysterectomy	
7.	32	2	...	Inoperable	
8.	33	3	...	,,	
9.	33	5	...	Ab. hysterectomy	8 months pregnant
10.	34	5	1	Vag. ,,	
11.	35	3	...	Inoperable	
12.	36	4	...	,,	
13.	37	3	1	,,	
14.	37	1	...	,,	
15.	38	8	...	,,	3 months pregnant
16.	38	1	...	Vag. hysterectomy	
17.	39	7	1	Inoperable	
18.	40	3	2	Vag. hysterectomy	
19.	41	1	...	Inoperable	
20.	41	4	...	,,	
21.	42	8	1	,,	
22.	42	7	6	,,	
23.	42	4	...	,,	
24.	43	4	...	Vag. hysterectomy	
25.	43	1	...	Inoperable	
26.	45	6	4	,,	
27.	46	7	2	,,	
28.	47	2	...	Vag. hysterectomy	
29.	47	7	4	Inoperable	
30.	48	7	...	,,	
31.	49	6	2	,,	
32.	49	4	...	,,	
33.	50	1	...	,,	
34.	51	1	...	,,	
35.	52	2	...	,,	
36.	53	8	1	,,	
37.	53	6	2	,,	
38.	53	6	1	,,	
39.	55	8	...	,,	
40.	55	3	...	,,	
41.	55	1	...	,,	
42.	55	6	1	,,	
43.	55	1	...	Vag. hysterectomy	
44.	59	6	...	Inoperable	
45.	59	7	...	,,	
46.	59	3	...	,,	
47.	61	9	1	Vag. hysterectomy	
48.	66	5	...	Inoperable	
49.	68	5	...	,,	
50.	70	2	...	,,	

An interesting feature in relation to cancer of the neck of the uterus is its occurrence in women many years subsequent to double ovariotomy. Examples of this are recorded in the *Transactions of the Obstetrical, London*, vols. xxxvii. 213, and xliii. 214.

Cancer of the Neck of the Uterus and Pregnancy.—It may be stated without fear of contradiction that the most appalling complication of pregnancy is cancer of the cervix. It is somewhat difficult to understand how a woman with cancer of the neck of the uterus can conceive, but it is quite certain that it happens when the disease is well established. From a careful inquiry, the writer is persuaded that this complication is not uncommon, but that the cases in which cancer of the neck of the uterus obstructs labour are unusual, and this is due to two circumstances—(1) that the cancer predisposes to abortion; and (2) that when it has advanced to such a stage as to fill the vagina with an obstructive mass, it has had such an effect upon the health of the mother that it endangers the life of the fœtus. This is a matter of some importance, because in considering the advisability of performing Cæsarean section in these circumstances, it is necessary to be certain that the fœtus is really alive. However, in very exceptional cases it has been found absolutely necessary to resort to this operation in order to deliver a dead and putrid fœtus.

The careful study of the literature relating to this complication shows clearly enough, that when a pregnant woman with early cancer of the uterus comes under observation in the early months her best hope lies in vaginal hysterectomy. In the later stages (fourth to seventh months) very good consequences have followed the amputation of the cervix, and this operation has been carried out very successfully and without disturbing the pregnancy. In the latest stages the best consequences have followed the induction of labour and the immediate performance of vaginal hysterectomy, for surprising as it may seem, the uterus, though enlarged from the pregnancy, can be safely extirpated through the vagina.

These methods of treatment only apply to cases where the cancer is in such a condition as to afford reasonable hope of a prolongation of life. When the disease is in an inoperable stage and the fœtus is dead, then after a little patient waiting abortion usually occurs. When there is reliable evidence that the fœtus is alive, then the pregnancy should be allowed to go to term; if the cancer affords an impassable barrier to the transit of the child, then Cæsarean section becomes a necessity.

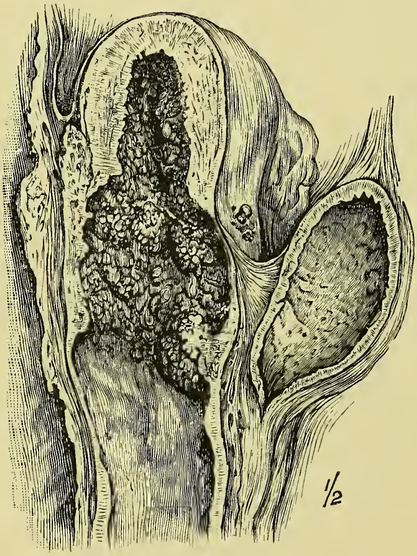

Fig. 8.—A cancerous uterus in sagittal section; a small process of cancer protruded through the uterus and infected the peritoneum, which contained thousands of secondary nodules. (From the writer's book on *Tumours*.)

Cancer of the Body of the Uterus.—This is much less frequent than cancer of the neck of the uterus, and it arises in the epithelium lining the cavity of the uterus and its tubular glands. There is very little accurate knowledge regarding its early stages, and the writer has only had one opportunity of obtaining a cancerous uterus before it had extended to the muscular wall. The disease remains for a long time restricted to the body of the uterus, and may creep into the uterine sections of one or both Fallopian tubes: it rarely invades the cervix, and then only in the late stages of the disease. It is apt to perforate the wall of the uterus and infect the peritoneum (Fig. 8).

It is only in the last fifteen years that the importance of cancer of the body of the uterus has been clearly appreciated, and this was due to the fact that there were no means available for the proper examination of the interior of the organ, and as a result the description of diseases of the endometrium were disfigured or obscured by a crowd of terms, such as senile endometritis, malignant endometritis, villous endometritis, and so on.

When the plan of mechanically dilating the cervical canal was introduced, so that the endometrium could be examined and fragments obtained for the laboratory, then light began to shine and we are in possession of some accurate data

As in other organs cancer of the body of the uterus consists of cell-columns, the cells being identical with the epithelial cells of the endometrium (Fig. 9). The disease assumes two distinct forms; thus it may appear as an eroding ulcer penetrating the muscular wall of the uterus, and sometimes even perforating the serous coat. In the common form it gives rise to luxuriant masses of soft succulent and vascular polypoid-like masses projecting into the cavity of the uterus, and this is the variety which used to be termed villous endometritis

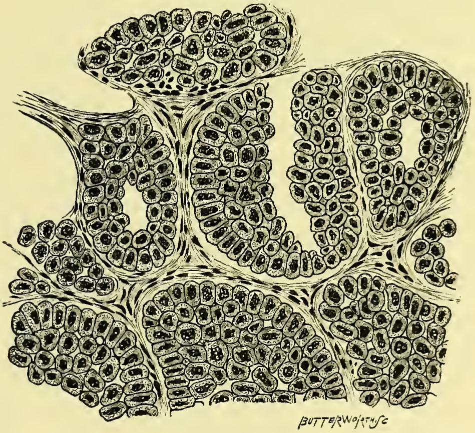

Fig. 9.—Microscopic characters of cancer of the corporeal endometrium: from a scraping. (From the writer's work on *Diseases of Women*.)

As the diagnosis of cancer of the body of the uterus is largely determined by the assistance of the microscope, it is essential for those who venture to give opinions on this point to be thoroughly familiar with the various abnormalities of the corporeal endometrium, and especially those which are known as glandular polypi.

Although in writings and in clinical work we treat very definitely of cancer of the cervical endometrium and cancer of the corporeal endometrium, it is well to understand that cases come to hand in which after the uterus has been removed it is extremely difficult on examining the organ to state positively whether the disease arose in the body of the organ or in the upper segment of the cervical canal (Fig. 10).

The writer is also convinced that there are two species of cancer arising in the corporeal endometrium, and that these species are not only distinct in their histologic features, but also in their gross characters and clinical aspects (Fig. 11).

The commoner species resembles, and indeed is very similar to that which attacks the cervical endometrium, except in the more perfect columnar type of the epithelium composing the cancer columns. The rarer species is that which has been described as "malignant adenoma" by more than one writer, and this is due to the fact that the normal features of the uterine glands are less distorted than in the common kind of cancer (Fig. 12). It is remarkable in forming large yellowish white masses in the endometrium, and causing great enlargement of the uterus.

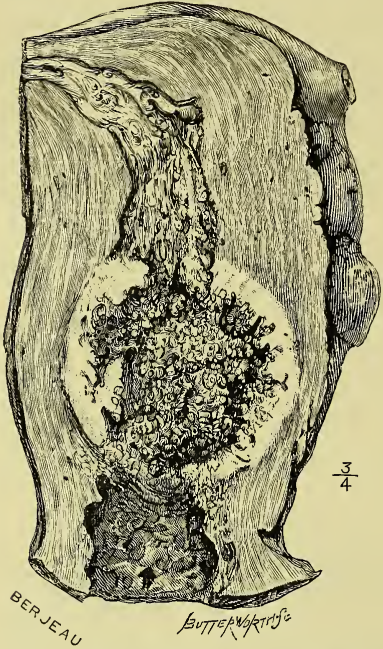

Fig. 10.—Cancerous uterus in sagittal section. A process of the cancer has crept into the right Fallopian tube. It was impossible to determine whether the cancer arose in the lower part of the body or the upper part of the neck of the uterus.

Cancer of the body of the uterus is unusual before the forty-fifth year; it is most frequent at or subsequent to the menopause. The majority of the cases occur after the fiftieth year. The majority of the patients are multiparous.

The signs which attract attention are fitful vaginal hæmorrhages after the menopause, followed by profuse, offensive, and often blood-stained discharges. The uterus on examination may seem scarcely enlarged; sometimes, however, it may be much bigger than usual. In the majority of cases the diagnosis cannot be established with certainty until the cervical canal is dilated and a fragment of the suspected cancer extracted and submitted to microscopic scrutiny. It often happens that when the cervical canal is dilated in this way the disease may be so advanced that there is no reasonable doubt in regard to the diagnosis, and in such circumstances it is sometimes to the best interest of the patient to complete the treatment by at once removing the cancerous organ. Even should it be decided to await a microscopic examination of the tissue, it is a useful measure to carefully

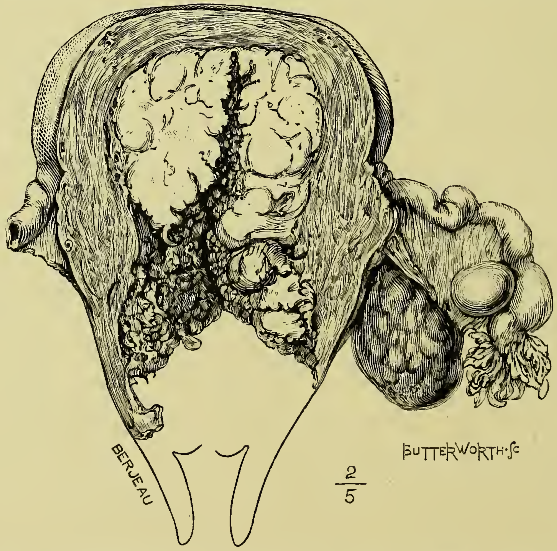

Fig. 11.—Uterus in coronal section: it is occupied with a cancerous mass, portions of which projected as polypoid processes with rounded ends into the cavity of the uterus.

remove with a blunt curette all the exuberant cancerous material, as this checks bleeding and limits decomposition of the necrotic portions of the cancer.

The only successful treatment available for cancer of the body of the uterus is hysterectomy. This operation may be carried out either by the vaginal route or by cœliotomy. The writer has carried out a series of operations by both methods, and has satisfied himself that though the immediate risks of the operation are the same by both methods, that the remote consequences are much better when the uterus is removed by the abdomen. It must be remembered that in cases where the cancerous growth is very luxurious the uterus may be very big, and its removal entire through the vagina becomes an impossibility, for it is a matter of the first importance to remove a cancerous uterus entire and without undue handling and squeezing, because the one great danger which women run in the operative treatment of this disease is cancer-infection. When the peritoneum is fouled with cancer material the cells possess so much power of independent growth that large masses of cancer spring up on the pelvic peritoneum in a few weeks and quickly destroy the patient.

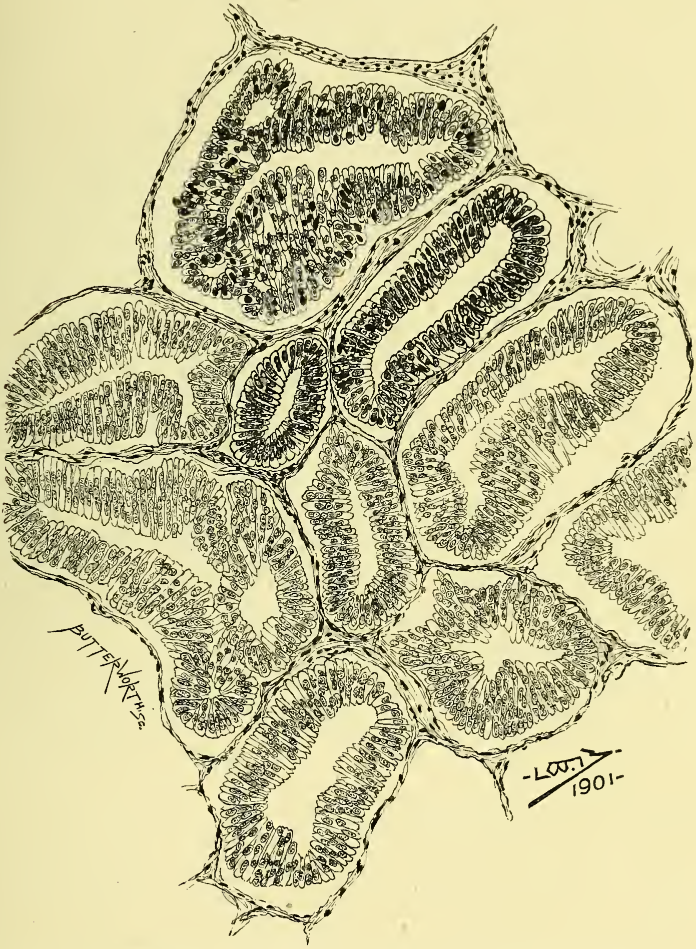

Fig. 12.—Microscopic characters of the "tubular" cancer shown in Fig. 11.

When the uterus is removed by the abdominal route the operator is not only able to completely extirpate the uterus, but he can remove the Fallopian tubes, ovaries, and adjacent segments of the broad ligaments. It has also this advantage, that it enables the operator to satisfy himself as to the extent of the disease, and also he can assure himself as to the absence of lymph gland infection and dissemination. Should either of these conditions be present then it would be useless to perform hysterectomy. It is a fortunate matter that the prospects of a patient after hysterectomy for cancer of the body of the uterus are infinitely better than in cancer of the cervix, and a number of cases can be brought together where women have had immunity from recurrence for five and even ten years. The great secret of success is early recognition of the disease and prompt treatment.

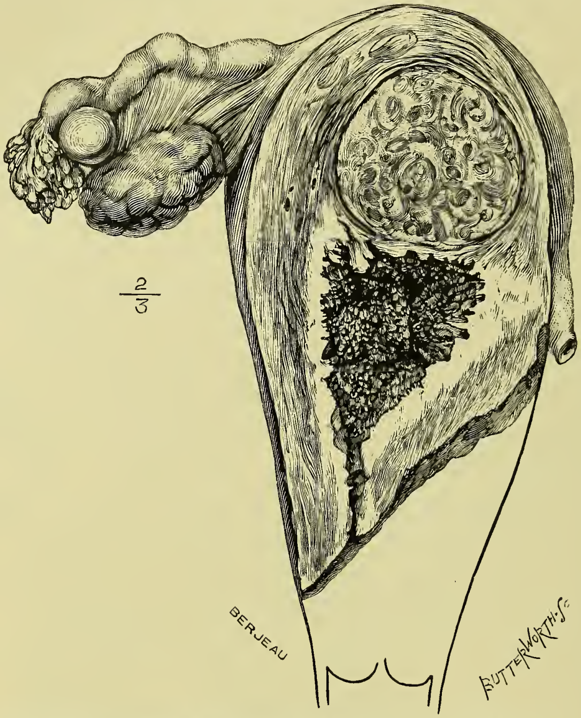

Fig. 13.—Cancer of the uterus complicated with a submucous fibroid. The uterus is shown in coronal section. Removed by abdominal hysterectomy from a sterile spinster.

Cancer of the Uterus and Fibroids.—Uterine fibroids are very common, so is cancer of the uterus, and as the maximum of frequency in relation to age is very near in the two diseases it is not a matter of surprise that the two conditions should frequently coexist. In some cases the two diseases may be seen in close proximity without interfering with each other, but when the capsule of a fibroid is invaded by contiguous cancer the tumour ulcerates and sloughs with great rapidity. Cancer of the body of the uterus is more frequently complicated with fibroids than cancer of the cervix, and it is a fact important to bear in mind that a woman who has attained her menopause, and is known to have fibroids, and especially if she be sterile, begins to suffer from irregular "issues of blood," this may be due to cancer of the endometrium (Fig. 13). It is always a suspicious sign and demands the most careful investigation. The matter may be put in the following aphoristic form:—*When a woman with uterine fibroids, having passed the menopause, begins to have irregular profuse uterine hæmorrhages, it is extremely probable that she has cancer of the body of the uterus.*

SARCOMA OF THE UTERUS.—The uterus, like other hollow muscular organs, is liable to sarcomata, but it would be difficult, indeed impossible, to state whether these tumours arose among its muscular elements or in the connective tissue of the endometrium. Before 1889 very few accurate facts were available in regard to uterine sarcomata, because it had become customary to describe all malignant tumours of the uterus as cancerous; but at that date Sänger and Pfeiffer independently described a remarkable variety of malignant tumour arising in connection with the parturient uterus, which has led pathologists to give very careful attention to all forms of malignant disease attacking the uterus.

Quite apart from the tumours described by Sänger and Pfeiffer, and which are considered in another article under the heading "DECIDUOMA" (see vol. x. p. 179), tumours with the characters of round-celled and spindle-celled sarcomata do arise in the uterus. They are, however, very exceptional. In one remarkable case described by Pernice a tumour grew from the neck of the uterus, and had the structure of a spindle-celled sarcoma; many of the spindles presented the transverse striation so characteristic of the tumours known as myosarcomata. The tumour recurred after removal, and the recurrent growth exhibited the ordinary spindle cells common to sarcomata. The disease in this case was rapidly fatal. In the few examples which have come under the writer's observation the tumours arose from the neck of the uterus by a somewhat broad stalk, and then formed dendritic masses in the vagina. In one case the tumour had the bulk of a cocoa-nut. These sarcomata are generally of the spindle-celled species, and the most marked feature is the rapidity with which they recur after removal. The patients are generally women between twenty and thirty-five years of age. This kind of sarcoma growing from the cervix is probably very rare, because the peculiar mass which fills the vagina, the narrow base from which it springs, the extraordinary rapidity with which it recurs after removal, constitute a clinical picture not likely to be mistaken; and they differ so much from the ordinary genera of tumours which attack the cervix that they would be sure to attract attention.

HYSTERECTOMY

Hysterectomy, as the surgical operation for the removal of the uterus is called, can be effected by two distinct methods. In one access is obtained to the uterus through an incision in the lower part of the belly wall—this is known as *abdominal hysterectomy;* in the other the uterus is extirpated through the vagina, and is termed on this account *vaginal hysterectomy.* It is somewhat remarkable that although the object of both operations is the same, namely, removal of the uterus, in the abdominal operation the surgeon takes every care to thoroughly close the peritoneum over the vaginal opening, but in the vaginal method the gap in the peritoneum, left after the removal of the uterus, is usually left open, and its edges merely fall into apposition.

The results of both methods in the hands of operators experienced in this class of work are among the most remarkable in surgery, and to ensure success the surgeon must exert himself to obtain a *rigid asepsis and perfect hæmostasis;* for this purpose it is essential to be extremely careful in the preparation of the patient for operation, as well as the materials and instruments used during the operation; the surgeon requires, above all things, to be scrupulously clean in regard to his own hands.

The choice of operation, as well as the details of the methods, are those which the writer adopts at the present time, and they are the outcome of several hundred hysterectomies performed for a variety of conditions.

Choice of Operation.—Cancer of the cervix suitable for operation is best removed through the vagina; even when it complicates pregnancy which has advanced to the seventh month, the fœtus and placenta can be extracted, and the uterus successfully extirpated. Fibroids co-existing with cervical cancer, unless they are very large, are not a bar to the vaginal hysterectomy, for they can be enucleated and extracted separately.

Cancer of the body of the uterus sometimes leads to great enlargement of the organ, then it is best removed by the abdominal route, but in a fair proportion of cases it is easily dealt with through the vagina. When cancer of the body of the uterus is complicated with a large fibroid then abdominal hysterectomy is the only judicious course.

There are conditions in which vaginal hysterectomy is a comparatively simple operation, for example, a small uterus and a capacious vagina; with the converse conditions the operation is often difficult, and it requires experience to enable the surgeon to judge when the relation between the size of the uterus and vagina are favourable or the reverse for the purpose of vaginal hysterectomy. It occasionally happens that an attempt is made to remove the uterus by the vagina, but in the course of the operation it is found impossible to extract the uterus, and the surgeon has to complete the work through an abdominal incision. Under such conditions some surgeons recommend removing the uterus and tumour piecemeal with the aid of the knife and scissors; this is termed *morcellement.* It is unwise to adopt this method with a cancerous uterus for fear of infecting the adjacent parts, and especially the peritoneum, with cancer.

It is better to remove the uterus by the vaginal method when the cancer is in the cervix, because a freer removal of the diseased parts is possible. When the disease is in the body of the uterus abdominal hysterectomy affords opportunity for a wider removal of the parts than the vaginal method. These are good working rules, but the latter is the one which is open to the greatest number of exceptions.

In operations of this kind a great deal depends upon the preliminary treatment of the patient, and for this purpose it is essential to have the assistance of a good nurse specially trained in this class of work. Such a nurse understands the methods of washing and disinfecting the vagina and pudenda, is apt at passing the catheter, and without fuss arranges and prepares the patient. It is good practice to have such a nurse in attendance for at least forty-eight hours before the operation, so that she may shave the hair from the pubes and labia, and, after thoroughly washing them with soap and warm water, renders the cutaneous parts as aseptic as possible with such antiseptic solutions as the operator is accustomed to use. The writer finds a solution of perchloride of mercury (1 in 5000) a very efficient antiseptic agent for the skin. The bowels should be very thoroughly emptied by enemata, and the patient should abstain from food or drink for at least six hours preceding the operation, and the bladder is emptied by a glass catheter immediately before the patient lies on the table. In regard to instruments they should be of metal throughout, as this facilitates the sterilisation whether by boiling or the application of dry heat.

The ligature material in common use is silk; it can be obtained of any thickness and length, and will stand boiling for half an hour or even longer without impairing its strength. The same is true of silkworm gut. Catgut cannot be boiled, and should be discarded as a ligature material. For dabs the writer employs square of Gamgee tissue carefully hemmed; they may be cut of any size or pattern, and should be boiled for one hour immediately before use. This material is cheap, capable of easy and efficient sterilisation, and has usurped animal sponges in surgical practice. They are burnt after each operation.

It is unnecessary to give minutely every detail in the preparation and sterilisation of material and instruments, for it may be assumed that no one would undertake such a serious operation as the removal of the uterus without some previous experience in operative surgery; most surgeons have had opportunities of witnessing the operation, or what is infinitely better, assisting a skilful and experienced surgeon in the performance of hysterectomy.

Abdominal Hysterectomy.—The preparation of the patient is described in the preceding remarks. For the satisfactory performance of this operation the Trendelenberg position is indispensable.

Instruments.—A scalpel; twelve hæmostatic forceps; dissecting-forceps; scissors; needles, straight and curved; silks of various sizes; volsella; six dabs of Gamgee tissue; two sponge-holders; silkworm gut. These instruments are necessary and are quite sufficient for good operators. The instruments should be immersed in warm sterilised water, and the dabs should be washed in water (at 100° F.) during the operation.

The anæsthetic depends on choice; some surgeons insist on chloroform. Ether administered by a skilful anæsthetist is the safest agent yet discovered for prolonged anæsthesia. Artificial temporary paraplegia from subdural injections of cocain or its allies is yet in the experimental stage.

It is important when the patient is in the Trendelenberg position to insure that the arms lie parallel with the trunk. This avoids pressure-palsy of the limbs, and prevents the hands and fingers being nipped when the table is restored to its horizontal position.

Steps of the Operation.—When the patient is completely unconscious, and the nightdress and other simple covering are isolated with sterilised towels, the surgeon freely incises the wall of the abdomen in the middle line midway between the umbilicus and the pubes. The actual length of the cut varies with the condition of the patient and the size of the uterus. Fat patients require long incisions, and it is easier to gain access to the uterus with a short incision when the parietes are thin and lax in women who have had children than in those that are barren. The length of the incision has no influence on the result of the operation, but a free incision greatly facilitates the necessary manipulations.

As soon as the uterus is exposed it is isolated from the intestines and omentum by dabs, and the uterus can be seized at the fundus by a volsella and drawn into the wound. Each mesometrium (broad ligament) is then transfixed and ligatured with silk in order to secure the ovarian vessels, or they may be seized with forceps and ligatured at a subsequent stage. When the surgeon wishes to leave the ovaries he secures the mesometrium between the uterus and the ovary, but when he decides to remove the ovaries as well as the uterus, and this is the preferable practice in cases of cancer, the mesometrium is ligatured near the brim of the pelvis on the outer side of the ovary. As soon as the mesometria are divided the uterus can easily be drawn out of the pelvis, and the uterine arteries are usually detected running upwards in the vascular tract on each side of the organ; these should be secured with forceps. A peritoneal flap is then turned down from the anterior surface of the uterus, care being taken not to injure the bladder. A similar flap is fashioned from the posterior surface of the uterus, and then the cervix is carefully enucleated from the upper end of the vagina. In favourable cases it often happens that when the peritoneal connections of the uterus are divided and the organ well drawn up, the mucous membrane attachment of the cervix will invaginate like the finger of a glove; the vaginal mucous membrane is then divided, and the surgeon is able to pass his finger into the vagina. The various bleeding points are secured with forceps, and any free blood or clot occupying the pelvis is removed. The uterine arteries are carefully secured with silk; the ovarian pedicles are transfixed and ligatured with silk as in the operation of ovariotomy. The anterior and posterior peritoneal flaps are brought into apposition with sutures, care being taken not to puncture the bladder. Any oozing points are seized and tied; then the edges of the peritoneal flap are finally secured with a continuous suture of thin silk, which extends from the ovarian pedicle on one side to that of the other; thus the vagina is completely isolated from the general cavity of the peritoneum, and any serious oozing which may occur finds a ready means of exit through the vagina.

The pelvis is then cleared of clot and dabs; the intestines are allowed to return into the pelvis. The forceps and dabs are carefully counted to insure that none is left in the abdomen. The incision is then closed in triple or single layers according to the practice of the surgeon. The writer always closes incisions below the umbilicus in three layers: (1) The peritoneum with a continuous suture of thin silk; (2) the fascia with interrupted suture of fine silkworm gut; and (3) the skin with a continuous suture of thin silk. When it is deemed advisable to drain the pelvis a thin strip of sterilised gauze is introduced into the pelvis and brought out at the lower angle of the incision.

The wound is dressed with a layer of sterilised gauze, and Gamgee tissue maintained in position by means of a manytail of flannel.

The patient is then restored to the horizontal position: all blood and clot is carefully removed from the vagina, and a thin strip of gauze is introduced to conduct away any blood or serum that may subsequently ooze into the vagina. A catheter is then introduced into the bladder and any urine it contains is withdrawn. The patient is then returned to bed.

After-Treatment.—This is conducted on the same lines as after ovariotomy, and as a rule the convalescence is a quick one.

Vaginal Hysterectomy.—The preparation of the patient has been already described. Instruments: Clover's crutch, duckbill speculum or Auvard's modification of this useful instrument, uterine sound, vesical sound, two volsellæ, scalpel, six hæmostatic forceps, dissecting forceps, three or four long-handled forceps with fenestrated blades, silks of various thickness, needles in handles and curved needles of various sizes, six Gamgee tissue dabs, glass catheter.

Steps of the Operation.—The patient is anæsthetised and secured in the lithotomy position by means of Clover's crutch, and arranged so that the perineum faces a good light. The vagina is then exposed by the duckbill speculum, and the cavity thoroughly irrigated with a solution of perchloride of mercury (1 in 1000), or something equally efficacious.

The operator seated at a convenient level passes the beak of the speculum into the vagina and seizes the cervix with a volsella. If there be much sprouting growth it is sometimes useful to detach it with the handle of a knife or a curette, and then thoroughly mop or reirrigate the parts. The assistant empties the bladder with a glass catheter, and then introduces the sound and keeps the surgeon informed of the relation of the bladder to the cervix throughout the first stage of the operation.

Stage 1.—The cervix is drawn down with a volsella, then with the scalpel the mucous membrane on its anterior aspect is transversely divided along a line well above the cancer, but sufficiently low to avoid wounding the bladder, which is then cautiously separated from the cervix with the forefinger or the handle of the knife. When the lower limit of the utero-vesical pouch is reached the peritoneum is divided with scissors and the fingers enter the peritoneal cavity. Throughout this stage the operator constantly informs himself of the exact position of the bladder by manipulating the sound.

Stage 2.—The incision in the mucous membrane is now carried round the cervix by means of scissors, and the recto-vaginal pouch is opened.

Stage 3.—The mesometria are dealt with in the following manner: A needle in handle armed with silk is made to transfix the connective tract close to the side of the cervix in order to avoid the ureter. The object of this ligature is to secure the uterine artery. Frequently the artery is distinctly visible, and is then picked up with forceps and tied by itself. As a rule, when the artery on each side is ligatured and the tissues adjacent to them cut with scissors the uterus can be drawn into the vagina and its fundus brought outside. The remaining upper segments of the mesometria are transfixed with silk and securely ligatured, and the uterus detached. These upper ligatures control the ovarian vessels and surround the Fallopian tubes. Should the ovaries or tubes be diseased, they can at this stage be removed by drawing them into the vagina and securing the pellicles by transfixion with silk. If all the lateral ligatures have been securely applied and hold, there should be no bleeding from the sides, but there is usually some oozing from the anterior and posterior folds. Any vessels which are freely bleeding should be secured with forceps and tied, but in regard to the posterior flap it is an advantage to seize it with a pair of fenestrated forceps and leave them *in situ* for twelve or even twenty-four hours.

The parts are then gently irrigated with warm sterilised water; bleeding points are secured with forceps or ligature, the whole cavity is gently mopped out, and a thin gauze drain inserted to allow any serum or blood to drain away; the bladder is then tested with a sound, the crutch removed, and the patient returned to bed.

The above method does not find favour with all operators, many prefer to compress the mesometria with specially constructed forceps and then cut the uterus away. The forceps are allowed to remain *in situ* forty-eight hours, and are then carefully removed. Each method has its advocates, and there are advantages and disadvantages associated with both. The employment of clamps materially shortens the operation. The writer after a careful trial of both methods prefers to ligature the main vessels and employ the clamps or forceps for the posterior septal flap.

After the operation the anterior and posterior flaps fall into apposition and unite in a few hours, so that it is not necessary to suture the flaps, which is moreover a dangerous practice, for it obstructs the escape of serum and blood, which may ooze even after the most carefully executed operation.

After-Treatment.—This is carried out on the same lines as those adopted for ovariotomy: the vagina needs to be considered in addition; for instance the gauze may be changed in thirty-six or forty-eight hours. When forceps or clamps are used they require to be taken away with the following precautions:—The patient's thighs are slightly raised and the knees gently separated, then the handles of the forceps are gently unlocked and the blades detached by a gentle twisting movement. Should bleeding occur in attempting to remove a clamp, it should be relocked and left for a few hours longer.

The temperature after vaginal hysterectomy often rises in consequence of the sloughing of the ligatured or compressed tissue: it may rise as high as 103° Fahr. and the discharge become offensive. When this happens the vagina should be gently mopped out with small dabs of cotton wool steeped in an antiseptic solution. By the ninth day some of the ligatures come away, and as a rule most of them are detached by the twentieth day. The patient is usually able to leave her bed about the end of the second week.

The Risks of Abdominal Hysterectomy.—The dangers are those common to all pelvic operations, such as shock, bleeding due to the slipping of badly applied ligatures, injury to the intestines, and particularly the bladder and ureters. Peritonitis may arise from failure in the preparations or contamination from the septic contents of the uterus, or dabs and instruments left in the belly at the time of the operation.

Later complications are suppuration, either in connection with the abdominal wound or from the bed of the cervix; thrombosis of the pelvic veins leading to œdema of the lower limb is a troublesome complication, and embolism has been a fairly frequent cause of death.

Cystitis may arise from two causes: the careless use of the catheter, or suppuration around a ligature involving the bladder, and occasionally actually penetrating this viscus.

Intestinal obstruction may follow this operation, due either to adhesion of the bowel to the stump in the pelvis or to the line of the abdominal incision, but it is fortunately rare.

The Risks of Vaginal Hysterectomy.—The chief of these are injury to the bladder or the ureters, injury to the rectum, sigmoid, cæcum, or small intestine, bleeding due to an artery slipping out of a ligature or the grasp of the forceps and retreating in the tissues.

The Sequelæ.—The more important are vesical and ureteral fistulæ, sepsis, and fatal peritonitis, death from intermediate and secondary bleeding, or from suppression of urine due to accidental ligature of the ureters, thrombosis of the pelvic veins and œdema of the limb, embolism, this is rare, and intestinal obstruction due to adhesions, but this is very unusual after vaginal hysterectomy.

Mortality.—The life risks of hysterectomy vary with the skill of the operator and the character of the case. In skilled hands the risks of abdominal hysterectomy for cancer varies from 5 to 10 per cent, in unskilled hands it may reach to 30 per cent.

In vaginal hysterectomy for cancer the life risk in experienced hands varies from 2 to 5 per cent. In unskilled hands the risk to life is not much greater, but the chances of damage to bladder, ureters, and bowel are much increased.

VI. **Uterine and Ovarian States, Insanity associated with.**

There certainly exists a definite relationship between the healthy growth, development, and function of the reproductive organs, and the healthy development and discharge of the cerebral and mental functions in both men and women. But in women one can go still further, and say that in many cases full physical and mental development is not complete until the reproductive organs have discharged their function in the reproduction of the race. There is an acknowledged difference between the mental characteristics of the old maid and the mother of a family. It is by no means so certain, however, that there are such diseases as uterine insanity and ovarian insanity. The terms uterine insanity and ovarian insanity do not convey to one any definite clinical picture as, for instance, the terms mania or melancholia do convey. I do not believe that the most skilful alienist, after an exhaustive examination of the women patients in all the asylums in Great Britain, could classify one of them with any certainty as a case of ovarian or uterine insanity.

There are well-recognised mental symptoms which are regarded as dependent upon certain changes in the uterus and ovaries, and for purposes of reference these conditions can be most concisely mentioned under the following divisions:—

1. Mental symptoms liable to occur during the period of physical development.
2. Mental symptoms liable to occur during the period of full functional activity of the uterus and ovaries.
3. Mental symptoms frequently coincident with the period of the climacteric.
4. Mental symptoms the result of surgical operations (ovariotomy, hysterectomy).

1. *Mental Symptoms liable to occur during the Period of Physical Development.*—During the period of life in which the reproductive capacity in women is coming to maturity (13-25 years) there is a tendency for women with a predisposition to the neuroses to suffer from morbid loss of self-control in speech, habits, and conduct. The various symptoms classified as hysteria

and moral perversions are legion, and may range from the slightest cases of exaggerated self-consciousness to symptoms so marked and unnatural as almost to constitute insanity. The marked outstanding symptom most characteristic of this period is impulsiveness, and may present itself in the motor equivalent of hystero-epileptic seizures. None of these mental abnormalities necessarily mean insanity, but they are danger signals indicating a lowered nutritive activity, and may pass into insanity under unfavourable conditions. During attacks of adolescent mania the delusions, actions, speech, and general conduct are often markedly sexual in character, and more especially during the menstrual periods. During such attacks of mania amenorrhœa is quite common, but this is probably a result, not a cause of the mental disease, as according to Dr. Cardew amenorrhœa is common amongst the senior classes in girls' schools without being accompanied by abnormal mental symptoms.

2. *Mental Symptoms liable to occur during the Period of full Functional Activity of the Uterus and Ovaries.*—Amongst women of a nervous temperament the monthly ovulation tends to produce regularly recurring mental symptoms which, although not sufficiently definite to be regarded as a distinct disease, are classified as the hysteropsychosis. When in addition to the natural strain of ovulation in such cases there is added some organic obstruction to the menstrual flow, misplacement or structural disease of the uterus or ovaries, one would expect to find and does find an exaggeration of all these symptoms. Many of these cases border very closely upon actual insanity, having at each menstrual period transient attacks of depression or morbid suspicions, and in some cases actual delusions and hallucinations, especially hallucinations of smell. The special sense of smell and the sexual functions in both men and women are very closely connected. In some instances this monthly neurosis imprints upon the brain habits which persist after the menopause. I have seen women, long past the climacteric, suffering from regularly recurring monthly attacks of dipsomania, each attack lasting for a few days. The history in each case being that these patients had been accustomed to relieve their menstrual pains with alcoholic stimulants. There are undoubtedly cases of insanity directly due to such menstrual pain; but, firstly, one must remember that there was almost certainly in each case a predisposition to mental instability, and the menstrual pain was merely the last link in the chain of adverse causes which precipitated the attack; and, secondly, such cases of insanity present no special symptoms which would enable a psychologist to diagnose them as being due to uterine or ovarian disease. In what percentage of the women patients in asylums does actual uterine or ovarian disease occur? Does operative treatment benefit cases so affected? These are questions at present unanswerable from statistics in this country. In the asylums in Great Britain and Ireland no systematic examinations of women patients have been made. In the United States of America and Canada, however, it appears to be in some asylums a routine practice to examine the women patients. Hobbs of Ontario states that out of 800 insane women patients 220 were examined, and 85 per cent of these had distinct lesions of the pelvic organs; 173 of these women were operated upon, 42 per cent recovered mentally, 24 per cent were relieved, 32 per cent were not improved. He believes that the introduction of gynæcological surgery into asylums as part of the regular treatment has raised the recovery rate from 33 to 51 per cent.

Ernest Hall states that out of 75 cases of insanity in women in private practice only four were found to be free from uterine or ovarian disease.

Out of 38 of these cases operated upon 6 recovered. Dr. Robe states that out of 100 women examined, 40 had lesions of the sexual organs, and he strongly believes in early operative treatment.

The question as to whether operative treatment is justifiable in insane women is often debated with considerable warmth. As a woman suffering from mental disease does not differ structurally from her sane sister, it is reasonable to suppose that treatment considered desirable and beneficial for the one cannot be injurious to the other. The consensus of opinion now is that operative procedure, if required, should be performed just as readily in the insane as in the sane woman, only in the former the consent of the patient herself, if possible, and certainly that of the friends, guardian, or curator should be obtained in writing. From time to time isolated and striking recoveries are recorded amongst insane women as the result of a gynæcological operation, and the recorder of the case may draw too sanguine conclusions from the example brought prominently under his notice. In connection with such cases it should be remembered that many insane patients recover just as marvellously after attacks of typhoid, erysipelas, boils, etc., and it is probable in many of these cases recovering after operation, that the recovery was due as much to the reaction following the shock of the operation as to the actual benefit accruing from the surgical interference.

Just at the end of the period of functional activity, and before the actual climacteric falls due, one occasionally meets cases of insanity known as "ovarian" or "old maid's insanity." Dr. Clouston says, "There is really no definite proof that the ovaries are either disturbed in function or diseased in structure in these cases. . . . The disease usually occurs in unprepossessing old maids, often of a religious life, who have been severely virtuous in thought, word, and deed, and on whom nature, just before the climacteric, takes revenge for a too absolute repression of all the manifestations of sex by arousing a grotesque and baseless passion for some casual acquaintance of the other sex, whom the victim believes to be deeply in love with her. . . . Usually her clergyman is the subject of this false belief. Out of several such cases which I can recall seven have had clergymen as their supposed wooers or seducers. In no case was there the very slightest possible ground for the notion."

3. *Mental Symptoms frequently coincident with the Period of the Climacteric.*—Climacteric melancholia is the classical form of mental disease to which predisposed and neurotic women are liable at the period of arrest of sexual function and uterine involution. Short of actual insanity there also exist at this period many mental symptoms closely allied to the psychoneurosis of adolescence and the period of fully-developed functional activity, with this difference, that whereas the neuroses of adolescence and adult life are not invariably of a depressing nature, the neuroses of the climacteric are depressing and are characterised by depression of spirits, deficient motor power, loss of the love of life, weakening of the social instincts, jealousies, and perverted sexual ideas. The delusion known as "pseudocyesis," or false pregnancy, is said to be common at this period of life in women. As a delusion among the insane I have seen it just as frequently in men as in women, and Dr. Clouston tells me he has very rarely seen it in private practice.

4. *Mental Symptoms the Result of Operations* (*Ovariotomy, Hysterectomy*).—Evidence as to the effect of gynæcological operations upon the mental condition of patients so operated upon is very conflicting. In nine years I have only seen two cases of acute mania which were apparently due to

removal of the appendages on both sides. Both women were nervous subjects of below thirty years of age, and both recovered.

It is recorded that out of 483 women operated upon by Dr. Savage of Birmingham, in whom he removed the appendages on both sides, four became insane. Dr. Keith, apparently, is of the opinion that removal of the ovaries alone does not produce any mental change, but removal of the uterus as well as both ovaries was followed by insanity in six cases out of sixty-four.

Lawson Tait stated that he had never seen a case of insanity follow hysterectomy, but, on the other hand, he had actually seen insanity cured and relief from neurotic symptoms follow upon operative procedure for diseases of the reproductive organs.

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Malformations of the Uvula are not uncommon. Occasionally it is congenitally absent, though more frequently its absence is due to destruction from ulceration. More or less completely bifid uvula is very common; or two distinct uvulas may be present, either side by side or one in front of the other. Even a case of triple uvula has been described; a normal uvula in the centre with a rudimentary one at each side.

Acute Uvulitis is usually only a part of an acute pharyngitis, though it may occur independently. It arises from exposure to cold, from septic infection, or from traumatism. Most commonly it is seen along with acute tonsillitis and peritonsillar abscess, or in association with tertiary specific or tubercular ulceration. The uvula may become greatly swollen and œdematous, and attain such length and thickness as to cause extreme distress. The writer can recall a case in which the uvula attained the length of the little finger and the patient had sat up all night with his uvula lying on his tongue, as any attempt to lie down brought on a severe laryngeal spasm.

An acutely inflamed uvula may be relieved by sucking ice, or by an application of cocaine (10 per cent to 20 per cent); but if there be much œdema, scarification or amputation gives the most rapid relief.

Chronic Uvulitis is practically always associated with chronic pharyngitis or naso-pharyngitis. The uvula is congested and relaxed, or slightly elongated and thickened. Any symptoms complained of in such cases will be found to depend on the accompanying pharyngitis and not on the slight changes in the uvula.

Elongated Uvula is frequently only an exaggerated form of chronic uvulitis, in which the congested and hypertrophied uvula has attained abnormal length. In another form there is no congestion or inflammatory change, but merely extreme length of the uvula as a whole, or great prolongation of the mucous membrane beyond the muscular tissue.

The causes of elongation of the uvula are the same as produce chronic pharyngitis. Lennox Browne believes it is specially common in persons who use the voice professionally during catarrhal attacks. The non-inflammatory form is in most instances primarily congenital in Bosworth's opinion.

In the great majority of cases an elongated uvula causes no symptoms, and in any case there is no correspondence between the length of the uvula and the amount of discomfort it may cause. This will depend rather on the irritability of the pharynx and the temperament of the individual. In one patient we see a greatly elongated uvula and yet there is no complaint, while in another a uvula only moderately elongated gives rise to much cough and irritation, which disappear on its partial amputation. It is therefore sometimes difficult to determine how far the uvula is the cause of the symptoms complained of, and we should first seek for, and remove, other sources of irritation before shortening the uvula. No doubt the uvula is frequently blamed for symptoms arising from granular pharyngitis or catarrh of the naso-pharynx, and its removal, being as simple as cutting the end off a piece of string, adopted without justification.

In a small proportion of cases an elongated uvula does produce well-marked and even distressing symptoms. Among these are persistent cough, made worse by lying down; the feeling of a foreign body, giving rise to frequent effort at "clearing" the throat; retching, or even vomiting, on getting up in the morning and after meals; and in rare cases, especially among those who smoke and drink to excess, laryngeal spasm. A few extreme cases are on record where the persistent cough and the emaciation caused by the frequent vomiting of food have led to a diagnosis of phthisis being erroneously made.

Treatment.—Where the uvula is only moderately elongated and the symptoms slight, astringent paints, lozenges, or gargles may be employed. If, however, the symptoms are distressing, and we are convinced the uvula is the cause, it is better to remove the redundant tissue at once. The best method of doing this is by means of the forceps and scissors devised for the purpose.

After applying a 20 per cent solution of cocaine to the parts, the tongue should be well depressed so as to obtain a good view, and the tongue-depressor then given to the patient to hold. Seizing the tip of the uvula with the forceps held in the left hand, it should be gently drawn forwards but not pulled upon, while with one cut of the scissors the excess of tissue is removed. In this way the cut, running from before backwards and upwards, leaves the wounded surface posteriorly. The whole uvula should never be removed, else it may be followed by persistent pain, difficulty in swallowing, and loss of vocal power. Our object should be to leave a uvula of normal length.

The amount of pain which follows this small operation varies greatly in different cases, and may be very severe for some days. All food should be soft and cold, and the patient should talk as little as possible. The sucking of ice is the best means of relieving the pain.

Though the writer has never met with it, quite a large number of cases of severe primary and secondary hæmorrhage after uvulotomy are on record.

New Growths of the uvula are rare, with the exception of papilloma, which may occur either as a sessile or pedunculated growth. Other growths which have been met with include angioma, mucous polypus, and primary carcinoma.

Paralysis of the uvula is common after diphtheria, and may occur alone or along with paralysis of the palate.

Vaccination.

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VACCINATION.—The value of vaccination as a protective against small-pox cannot be correctly estimated without an acquaintance with the severity and prevalence of small-pox in the pre-vaccination era. If the evil was a trifling one, legislation in support of its prevention cannot be defended. But if the evil was great, and if experience proves that vaccination protects from small-pox, legislation may properly enforce it on a population of which a very large proportion can never estimate correctly the importance of the danger from which it is intended to save them.

What, then, is the record of history as to the effects of small-pox before it was modified by vaccination? It is unnecessary for our purpose to enter upon this subject from an antiquarian standpoint. The point we have to consider is this, Was small-pox a grave social danger in the centuries immediately preceding the introduction of Vaccination? History proves without doubt that it was. In communities which were in touch with each other, small-pox was essentially a disease of infancy, not because the infection was only taken by children, but because the majority of the adult population were protected by having had the disease in childhood. Of the four great plagues of infancy, measles, whooping-cough, scarlatina, and small-pox, the last was the most common and the most dreaded. It attacked almost all exposed to the infection; it killed at least one in seven of those attacked, in many epidemics as many as one in three.

The type of the disease, then as now, varied much in severity. In all but mild cases it was an illness of the gravest suffering, many of its victims were blinded for life, and a large majority were terribly disfigured. The one ameliorative fact was that the disease was in large measure self-protective. Children who struggled through it did not, as a rule, have it again. They were protected by their early sufferings; so that where small-pox returned at short intervals in a community, as it did in large towns, the adult population was, for the most part, immune; most of them having had it in childhood. The case was different in isolated country districts and out-of-the-way corners of the country, where the greater part of the adult population had never before been exposed to the infection. If in such a locality small-pox was by chance introduced, it was not limited to the children of the community, it attacked all ages equally, in proportion to their exposure to infection. Infection, then as now, depended upon the co-existence of the two factors, the contagious poison and the contact with it of unprotected people. Adults who had not gained immunity by going through the disease in childhood were almost sure, if they moved about the world at all, to meet the contagion at some time and to take it. One of Horace Walpole's correspondents says, "Poetry is as universally contagious as small-pox; every one catches it once in a life-time at least, and the sooner the better." The immense effect of a large part of the adult population being immune to a second attack of the disease is seen if we compare even severe small-pox epidemics in England in the seventeenth or eighteenth centuries with those which occurred when the disease was introduced into new places where no one had had it previously, and where, therefore, no one was immune. Prescott, in his *History of Mexico,* describes the ravages of the disease in 1520. He says:—

> Maxixca, the old lord of Kascala, had fallen a victim to that terrible epidemic—the small-pox, which was now sweeping over the land like fire over the prairies, smiting down prince and peasant, and adding another to the long train of woes that followed the march of the white men. It was imported into the country, it is said, by a negro slave. . . . The poor natives sought relief in their usual practice of bathing in cold water, which greatly aggravated their trouble. It spread rapidly over the country to the Astec capital where Montezuma's successor fell one of its first victims. Thence it swept down towards the borders of the Pacific, leaving its path strewn with the dead bodies of the natives who, in the strong language of a contemporary, perished in heaps like cattle stricken with the murrain. . . . So great was the number of those who died of this disease that there was no possibility of burying them, and in Mexico the bodies were thrown into the canals then filled with water, till the air was poisoned with the stench of putrid bodies.

Catlin, in his *History of the North American Indians,* mentions that of a population of 12,000,000, 6,000,000 fell victims to small-pox. In another place he says, "Each tribe has had this exotic disease in turn, and in a few months it has lost one-half or more of its numbers."[1] In 1707 an epidemic in Iceland is said, from records furnished by the Government of Denmark, to have killed 18,000 out of 50,000 of the inhabitants, *i.e.,* 36 per cent. In Greenland in 1734 an epidemic is believed by Sir John Simon to have destroyed two-thirds of the whole population. In Mexico and Greenland there is no history of any earlier epidemic; in Iceland there had been none for a number of years, probably not since 1616. Therefore in all three cases no considerable section of the population would be protected by a previous attack. How severe a scourge small-pox was towards the end of the seventeenth century is plainly seen in the pages of Evelyn and Pepys. From 1684 to 1695 Evelyn's Diary abounds in references to the disease and to its terrible results.

> *December* 1684.—The small-pox very prevalent and mortal.
>
> *7th March* 1685.—My daughter Mary was taken with small-pox, and there soon was found no hope of her recovery. A great affliction to me.

A few days later there is mention of her death:—

> Oh, dear sweet child! how shall I part with all this goodness and virtue without the bitterness of sorrow and reluctancy of a tender parent? . . . Never can I say enough; oh dear, my dear child, whose memory is so precious to me. . . . Thus lived and died. . . . The joy of my life.

Three months later it is noted that—

> Mr. Hussey, who made love to my late dear child, died now of the same cruel disease.

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[1] Vol. ii. p. 150, revised edition.

> *27th August* 1685.—My daughter Elizabeth died of the small-pox soon after her marriage.
>
> *15th April* 1686.—The Archbishop of York now died of small-pox.
>
> *December* 1694.—The small-pox increased exceedingly, and was very mortal. The Queen died of it on the 28th.
>
> *13th January* 1695.—The deaths in London by small-pox increased to 500 more than in the preceding week.

This was for London only. The epidemic in London, in the winter of 1901-1902, with a population of 5,000,000, killed, from August 1901 to February 1902, 600 people; but in Evelyn's time the increased mortality from one week to the next was said by him to be 500, and this in a population of probably less than one-twelfth of the present number in London.

Pepys's Diary tells the same sad story. The history of the deaths caused by small-pox among the royal families of Europe is a further confirmation of its great prevalence and severity. Mention has been made of the death of Queen Mary in her thirty-third year. The king also lost from the same cause both his parents, an uncle, and two cousins. He had it himself very severely, and recovered with a constitution damaged for life. In Austria it killed Joseph I., and in the eighteenth century two empresses, six other members of the imperial family, an Elector of Saxony, and the last Elector of Bavaria. Also a Dauphin (1711) and a King (1774) of France, a Queen (1741) of Sweden, a Queen of Naples, and an Emperor (1727) of Russia. In fact, the high mortality in royal and aristocratic families illustrates the danger of trying to keep children away from the contagion in their youth. The risk of infection in later life was greatly increased by the care exercised to preserve the children of great families in early life.

Horace Walpole's letters are full of references both to small-pox and inoculation.

> Lord Dalkeith is dead of the small-pox in three days. It is so dreadfully fatal in his family, that besides several uncles and aunts, his eldest boy died of it last year, and his only brother, who was ill but two days. . . .—Vol. ii. p. 203.
>
> Lord Waldegrave is just dead of the small-pox. . . . His brother and sister were inoculated, but it was early in the practice of that great preservative, which was then devoutly opposed; he was eldest son and weakly.—Vol. iv. p. 65.
>
> A very curious list might be compiled of the heads of great families left without heirs-male by the small-pox; the two most remarkable are the familiar friends, Queen Anne and the Duchess of Marlborough.

In vol. vi. Walpole comments on the death of Louis XV. from small-pox, and on the devotion of his daughters who tended him, and who both caught it. On page 95 he notes, "The whole Blood Royal of France is now recovered from the small-pox." In an earlier volume he says, "Prince George (afterwards George III.) is ill of small-pox"; and on page 327, "Lord Beauchamp, only son of the last Duke of Somerset of that branch, died of small-pox after a four days' illness.

Ben Jonson's epigram may also be quoted:—

> Envious and foule disease, can there not be
> One Beautie in an age and free from thee?

Macaulay, in his essay on Sir William Temple and Dorothy Osborne says:—

> Poor Mistress Osborne fell ill with small-pox, and though she escaped with her life, lost all her beauty. To this most severe trial the affection and honour of the lovers of that age was not unfrequently subjected. Our readers probably remember what Mrs. Hutchinson tells us of herself . . . how her beloved colonel

"married her as soon as she was able to quit the chamber, when the priest and all that saw her were affrighted to look on her."

If, leaving these general statements as to the prevalence of small-pox, we try to ascertain the actual percentage of the population of London or any other town that died of the disease before the vaccination era, we are met by the fact that there was in London no registration of births till early in the nineteenth century; and that the only record of deaths up till the year 1838 were the bills of mortality or lists of burials kept for all the parochial burial grounds. The London bills of mortality were first compiled by order of Thomas Cromwell about 1538, and the systematic keeping of them was begun by the Company of Parish Clerks in 1593. Each parish clerk was directed to bring "to the Clerks' Hall, weekly, a note of all christenings and burials." Obviously, calculations on such a basis cannot pretend to have any minute accuracy. The records were, however, carefully studied by Sir John Simon, and the conclusion he arrived at was that from 1660 to 1679 small-pox in London had killed annually 4170 per million of inhabitants, and that from 1746 to 1755 the rate was about 3000 per million. To estimate correctly the small-pox mortality rate for all England is still more difficult. It would certainly be lower than in London, and in some isolated parts of the country it might be entirely absent for a long term of years. Some of the provincial towns were in advance of London in the matter of registration; and here and there it is possible to study the mortality caused by small-pox towards the end of the eighteenth century with considerable precision. In Glasgow it was 4700 per million; in Manchester, 4300; in Liverpool, 6400; in Chester, "a place of incredible healthiness," 3300; in Boston, 2700; all per million of population. Occasionally we can get the exact record of a given year. At Leeds, for instance, in 1798 more than one-third of the total mortality was caused by small-pox. The numbers are 272 out of 779.

In 1801, when the first census was taken, London, with less than three-quarters of a million of inhabitants, had a small-pox mortality of over 3000. A census exists of the small town of Ware, taken soon after an epidemic in 1722, and with the special view of recording the facts as concerning small-pox—in itself good evidence of the importance of the disease. The total number of inhabitants was 2515. Of these, 1601 had had the small-pox before the recent epidemic; 612 had just had it; 72 had died; and the rest of the entire population (302) are described as "those who have to have their small-pox." That accounts for the entire population of Ware. Evidence abounds pointing to the almost universal liability to the disease. Advertisements for servants mention that they must have had the small-pox. Sir Gilbert Blane told a Committee of the House of Commons that at the end of the eighteenth century there was scarcely an adult person to be met who had not had the small-pox. It even came to be considered a grave disadvantage not to have had it in childhood. Sir Gilbert Blane spoke in this sense to a Committee of the House of Commons. He said:—

> Such as have not had the small-pox in the early period of life are not only rendered unhappy, but likewise in great measure unfit for sustaining many of the most useful and important offices. Few people would choose even to hire a servant who had not had the small-pox, far less purchase a slave who had the chance of dying of this disease. How could a physician or surgeon who had never had the small-pox himself attend others under that malady? How deplorable is the situation of females who arrive at mature age without having had the small-pox! . . . How often is the affectionate mother forced to leave her home and

abandon her children at the very time when her care is most necessary! Yet should parental affection get the better of her fears the consequences would often prove fatal.

In the Final Report of the Vaccination Commission we read, on page 13:—

> Perhaps the most striking evidence in favour of the conclusion as to the great prevalence and high mortality of small-pox in Western Europe in the eighteenth century and earlier, is to be seen in the fact that the chance of taking the disease and of dying from it was made the subject of mathematical treatment by distinguished mathematicians of the time. Thus Daniel Bernouilli, writing in 1760-65, takes as one of the bases of his calculation the datum that small-pox carries off the $\frac{1}{13}$th or $\frac{1}{14}$th part of each generation.

We may compare this estimated rate of the eighteenth century's small-pox mortality with that of scarlet fever at the present time. For twenty years, from 1875 to 1894, the average annual mortality from scarlet fever in England and Wales was 430 per million, which is about one-ninth of the small-pox mortality in the pre-vaccination century as estimated by Dr. Farr. It must always be remembered, moreover, that those who escaped with their lives from a bad attack of small-pox had gone through a time of great suffering. Few illnesses are as painful as small-pox of even moderate severity. No doubt epidemics varied very greatly then, as they do now, in the severity of their type of the disease; but it is apparently well within the mark to say that in England generally small-pox killed over 2000 per million in each year, and that in London and other large towns the rate was often over 4000 per million. Let us see now what vaccination has done to reduce this terrible mortality.

The first attempt to do anything systematic in England against small-pox was made in 1720. It had long been known in China that a much milder form of the disease could be produced by putting some of the variolous matter under the skin of the person to be infected. This process was known as "buying the small-pox." Dr. M'Vail has found the same expression in Wales and in various parts of Western Europe, and he thinks it likely that the practice of inoculation had been introduced from the East into scattered parts of Western Europe, and had by degrees been forgotten and disused. It is obvious that the practice was likely, in careless and ignorant hands, to do at least as much harm as good. The credit of the reintroduction of inoculation into Europe belongs to Lady Mary Wortley Montagu, whose husband was at that time ambassador at Constantinople. She heard of the method, and after considerable inquiry into its results she made it known in England. Small-pox being then one of the most certain sources of every general practitioner's income, she thought the medical profession would be her most vigorous opponents. Nowadays we often hear that doctors support vaccination because it adds to their income; it is forgotten that the earnings from this source are insignificant compared to those obtained from attending patients through the illness of small-pox. Lady Mary writes thus to a friend:—

> I should not fail to write to some of our doctors about it if I knew any of them that I thought had virtue enough to destroy such a considerable branch of their revenue for the good of mankind. But that distemper is too beneficial to them not to expose to all their resentment the hardy wight that should undertake to put an end to it. Perhaps, if I live to return, I may, however, have courage to war with them.

Lady Mary had her little daughter inoculated in England, and the practice was slowly brought into fashion. But the early results were not very satisfactory. Up to 1728 only 897 cases were inoculated in England, and of these 17 died, so that the induced disease was evidently not always a slight affair. This was disappointing, as safety had been promised. During the immaturity of a new idea or practice there are always a crowd of timid folk who condemn every novelty that does not come before the world in its final and perfected form. Few people have knowledge or insight enough to be patient with that which is new and in its developmental stage. Inoculation was quite out of fashion from 1728 to 1740, when it was again revived. Two things were obviously against its general usefulness. The inoculated disease was not always mild, and it was contagious. Gradually, as time went on, it was found possible to guard against these two disadvantages. By taking the variolous lymph earlier in the disease, by introducing it under the skin in a better way, and by careful regulation of the patient's life before the operation the illness was made exceedingly light. Inoculating for small-pox became a special part of the medical art, and men practised it almost to the exclusion of everything else. About 1763, for instance, two brothers, named Sutton, enjoyed immense popularity as safe inoculators. They boasted of having had upwards of 10,000 cases with no deaths. The other disadvantage of inoculation was met by isolating patients with the inoculated form of the disease so carefully that persons not immune from having had small-pox had nothing to do with them. With an adult population who were largely protected from the disease by having had it already, the necessary quarantine was not impossible, but it required to be accepted and enforced in a thorough-going way. Children and young people who were inoculated had to be segregated and surrounded by immune adults for several weeks. The Scotch people, with their excellent sense, and with the attention to detail which has conduced so much to their reputation in professional and commercial life, as gardeners and cooks, etc., seem to have been able to get all the good that was possible out of inoculation then, as for the most part they do now out of vaccination. Dr. M'Vail brought under the notice of the Commission an old book, Sir John Sinclair's *Statistical Account of Scotland*, which extended from 1790 to 1799. Sir John had asked the parish ministers of Scotland for information on a number of details about their parishes. He did not ask about small-pox, but many of his correspondents mention inoculation as a valuable means of protecting the population from the disease. People who are opposed to vaccination often assert that the prevalence of small-pox at the end of the eighteenth century was due to its spread by inoculation. In careless hands this might be the result, but Sinclair's book proves that it was not the rule in Scotland. Among the many statements in favour of inoculation a few may be quoted.

"The former virulence and ravages of small-pox are much abated in this parish (New Abbey, Kirkcudbright) owing to the ministers performing the operation of inoculation to a considerable extent, and with the greatest success." At Portingal in Perthshire "it may be added that fewer children die in the Highlands than almost anywhere, especially since inoculation has been so universally practised, which it has been for a good many years back, to the saving of many lives." At Kilmuir, Skye, "in former times the small-pox frequently prevailed to a very great height, and sometimes almost depopulated the country. The people in general are now so well convinced of the propriety of inoculation that it is become the practice universally, and many useful lives are saved by it." At Durness, Sutherlandshire, "the small-pox used formerly to cut off great numbers of the children, but inoculation was introduced here more than thirty years ago . . . and it has been attended with the greatest success."

In one or two places permanent increase of population was attributed by the writers to the practice of inoculation. At Largo, Fifeshire, it is stated "Few children are now cut off by small-pox, as inoculation is generally introduced with remarkable success. During twenty years practice our surgeon has not lost one patient." These statements were made by parish ministers relating the impression the facts had made on their minds. They wrote independently of each other, and their testimony is worthy of attention.

Horace Walpole[1] may again be quoted "Oh, your poor young Queen of Naples who has got the small-pox and will lose her beauty, if not her life! How much stronger superstition and prejudice are than maternal love, when all these deaths cannot open the Empress Queen's eyes (Maria Theresa) in favour of inoculation! But she has escaped herself, and that will close them faster than ever." And again, "I wonder all the princes of Europe are not frightened *into* their wits—why they die every day! and might avoid it, most of them, by being inoculated. Mr. Sutton would ensure them at 12 pence a head. He inoculates whole counties, and it does not cause the least interruption in their business. They work in the fields, or go up to their middles in water, as usual. It is silly to die of such an old-fashioned distemper!" In another letter Walpole speaks of "his zeal for the cause of inoculation." George III.'s eighth son, Octavius, died in a convulsion on the sixth day after inoculation. Walpole says that even though it may be true that the death was due to the operation "is one child lost an argument against millions preserved? Did not another child die, also from convulsions, two years ago, who had not been inoculated?" The era of inoculation, however, was not a long one. It was destined to be superseded by vaccination.

In the year 1769 Edward Jenner, a medical student from Gloucestershire, came to London and lived with John Hunter as one of his house pupils. Hunter was always questioning Nature in one direction or another. He had a genius for observing facts, and for putting them into their true relation with each other. To this questioning and observing man Jenner reported that in the midst of an epidemic of small-pox a dairymaid had said confidently to him, "I shall not take small-pox, I have had cow-pox." What did this mean? Hunter said in answer, "Do not think, try; be patient, be accurate"; meaning, no doubt, be sure of your facts before you theorise upon them, and when you are sure test them experimentally. We know now that the tradition which Jenner heard from the dairymaid was common not only in Gloucestershire, but in many other parts of England, Ireland, and the Continent. It has been traced in eighteen English counties. The practice of inoculation was practically an experiment on a large scale testing the truth of the tradition. Whenever small-pox was introduced into a dairy or cheese-making district, hundreds of people would seek the protection of inoculation. Every practitioner would look carefully into the causes of failure, when he had inoculated without success. He heard in many cases that the subject of the operation had had sores on her hands, contracted from the cow, and that the dairy people believed these sores protected against small-pox. If this happened again and again, and the dairymaids who could not be inoculated did not get small-pox when exposed to it, the practitioners would gradually begin to respect the traditional belief. So strongly was this tradition held that we now know of a farmer named Jesty who actually took lymph from a cow and inoculated his wife and children with it to protect them from small-pox, and that this was done before Jenner's memoir appeared. Dr. M'Vail quotes from Pearson's *Inquiry into the History of Cow-pox,* much evidence of the wide diffusion and strength of the tradition about cow-pox.

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[1] *Horace Walpole's Letters*, vol. v. p. 71.

> Mr. Rolph says there is not a medical practitioner of even little experience in Gloucestershire, or scarce a dairy farmer, who does not know from his own experience and that of others that persons who have suffered the cow-pox are exempted from the agency of the variolous poison. . . . So, too, Mr. Bragge, many years before, had inoculated over fifty people, of whom three had had cow-pox, and these he therefore charged with an abundance of matter, but to no purpose.

Dr. Seaton, in his Handbook, refers to a German newspaper dated 1769 in which mention is made of cow-pox being often seen about Göttingen, of milkers being affected by it, and of "their being protected thereby against small-pox." From the time Jenner heard of the tradition he pondered over it. He lived the life of a busy country doctor for thirty years. But about midway in this time, in 1780, his pondering led him to a new idea in connection with cow-pox, and it is upon this idea that his fame is based. It flashed upon his mind that if the tradition referred to was true the protection from small-pox might possibly be transferred directly from one person to another, and then that every one might be made immune to the poison of small-pox. Can we not imagine the delight that such a conception as this would bring to one who knew, as every doctor did then, the misery and suffering caused by small-pox? Jenner was afraid to mention his idea publicly; but one day, riding with his intimate friend Gardiner, from Gloucester to Newport, he confided it to him. Gardiner said that Jenner did so "with deep and anxious emotion," and that he said, "Gardiner, I have entrusted to you a most important matter which I firmly believe may prove to be of inestimable value to the human race." He added, "Say nothing of this; if it fails, all would laugh at me, and something untoward may happen." Year by year he brooded over the idea, and watched for an opportunity of testing its truth. Finally, sixteen years later, his chance came. In May 1796 he was able to take vaccine lymph from a person who had contracted cow-pox, and with it to inoculate a boy who had not had small-pox. Vaccine vesicles resulted. Six weeks later he tried to inoculate the boy with small-pox lymph and it failed. He wrote to Gardiner to tell him the result of the experiment, and added, "But now comes the most delightful part of my story. On July 1st the boy was inoculated for small-pox, but without any result." After this Jenner went on passing the vaccine lymph through a succession of people, and then inoculating them for small-pox, always with the same result; those in whom he had produced vaccine vesicles did not respond to the small-pox inoculation—they were immune to the contagion. Two years were thus occupied; then he came to London and published his *Inquiry into the Causes and Effects of the Variolæ Vaccinæ: a disease discovered in some of the western counties of England, particularly Gloucestershire, and known by the name of Cow-pox.* It is worth noting that Jenner boldly called cow-pox small-pox of the cow; also that he did not claim to have had any share in its discovery. In the hundred and more years since the *Inquiry* appeared, after endless controversies on the subject, Jenner's name for cow-pox has held its place. We believe as he did that the two diseases, cow-pox and small-pox, are essentially from one stock, and that either in cow-pox the virus has been attenuated by passing through the constitution of the cow, or that it has become much more virulent by passing through the system of the human. With the exception of a few cranks the whole of the civilised world accepted the boon Jenner had been able to offer it with enthusiasm and joy. Every one knew then what small-pox was, almost every one had lost relatives from it; a still larger number had seen the fair young faces around them disfigured for life by its ravages. Honours poured in upon Jenner. Almost every crowned head in Europe did him honour. We hear of his being asked to appeal to Napoleon on behalf of a Gloucestershire man taken prisoner in the wars. As Napoleon wrote the order of release he said, "I can refuse nothing to *that* man." The great majority of mankind, when Jenner had established his facts, welcomed with enthusiasm the deliverance he had brought them. Much, no doubt, remained to be learnt about vaccination, and on one important point Jenner himself went wrong. He thought the protection acquired through the agency of vaccine lymph would prove to be as lasting as that conferred by having had the small-pox itself. The early observers had to find out when to take the lymph from the vaccine vesicle, how soon after vaccination its protective influence would be felt, if one vesicle was as efficacious as three or four, and if the modified disease was ever in itself a source of danger. Probably the importance of each of these points was only gradually appreciated. The attention of every one was fixed on the point of greatest moment, viz.: "Have we in vaccination a possible mode of escape from the demon of small-pox?" They would not be able at first to think of much more than this.

One of the most interesting episodes in the early history of vaccination was the method adopted to convey the newly found boon to the Spanish-American dominions. The ravages due to small-pox at the time of the conquest of Mexico were still remembered. Other severe epidemics had frequently occurred. The difficulty of conveying the lymph across the Atlantic was considerable. It was not the age of swift steamers, cold chambers, or capillary tubes. Ingenuity had to find a way. Children who had not had the small-pox were sent to Spanish America, one or two being vaccinated each week during the voyage, and in this way the lymph arrived at its destination in a fresh and active condition. The supplement to the *Madrid Gazette*, dated 14th October 1806 contains the following account of the expedition which had started from Corunna on 20th November 1803:—"On Sunday, 7th September last, Dr. Francis Xavier Balmis, surgeon extraordinary to the king, had the honour of kissing his Majesty's hand on the occasion of his return from a voyage round the world, executed with the sole object of carrying to all the possessions of the Crown of Spain situated beyond the seas the inestimable gift of vaccine inoculation."

> The expedition consisted of three frigates, with several physicians and twenty-two children who had not had the small-pox. . . . The children, many of whom were very small, were placed under the care of a matron, and the greatest attention was paid to their cleanliness and comfort. At New Spain they made a fresh start with twenty-six more children. Material for vaccination was lavishly distributed through the northern part of Spanish America, and in each capital a central society was formed. Half of the expedition went to the Philippine Islands, Macao, and Canton, and the other half to Peru. This section was wrecked, but happily the sub-director, his three physicians, and the children came to no harm. The expedition was often publicly received by the bishops, military governors, and persons of the greatest distinction, who took into their arms the little children who were to carry the cow-pox to the indigenous Americans and the Malays of the Philippine Islands, and returned thanks to God for having been the witnesses of so happy an event.

If we now inquire what was the immediate effect of vaccination in the early years of the nineteenth century, we must remember that throughout the civilised world there were two influences which aided vaccination then more powerfully than they have ever done since. Every adult person at that time knew from personal or family experience what small-pox was. Every one had lost relatives by it; he had seen with his own eyes what it involved. There is no such lesson as to the value of vaccination as an experience of small-pox; it was a lesson which all had learnt. Moreover, the adult population was in a very large measure, as has already been said, protected by having had the disease in childhood. It was not therefore necessary to vaccinate every one. If the children were vaccinated a large proportion of the entire population was protected. These two influences worked powerfully in support of vaccination in the early years of the last century. There seem to have been few or no vaccination laws. Fear of small-pox influenced the majority of parents; careless and indolent people were successfully controlled by public opinion and by indirect pressure. In Copenhagen, for instance, in the twelve years before vaccination was practised, an average of 458 persons each year had died of small-pox. From 1802 to 1818 the average mortality dropped from 458 to 9·8 in spite of the absence of direct compulsion in support of vaccination. No child was admitted into the public schools, no one could be confirmed or apprenticed to a trade, no one could be married without proving that he had either been vaccinated or had had the small-pox. Auspach, in Bavaria, furnishes a similar example. Here the annual average mortality from small-pox had been 500. In 1800 there was a severe epidemic which killed 1609, and which no doubt also protected from future attacks some 5000 or 6000 persons who had survived the illness. In the next eleven years, by the aid of infantile vaccination, there was a total small-pox mortality of five only. Much the same thing occurred in many English towns. Parental anxiety to escape an evil so familiar and so justly dreaded, led to a large amount of infant vaccination, and the adult population was in considerable measure immune. At Norwich, for example, from 1810 to 1818, there was scarcely any small-pox, not a single case from 1813 to 1818. Gradually the knowledge and memory of small-pox died out, the anxiety about it disappeared, the public appreciation of the immense value of infant vaccination diminished, the children vaccinated ten or fifteen years earlier were outgrowing their protection, the adults who had had small-pox in their youth were passing away, and as soon as the contagion was introduced a large number of unprotected people were prepared to receive it. The Norwich epidemic of 1819 was a severe one. Cross estimates that one-thirteenth of the whole population suffered; there were 530 deaths.

This brings us to the question, How far is the protection of vaccination absolute and lasting?

It is a familiar fact about almost all the contagious fevers, that, as a rule, one attack protects against subsequent ones. How this immunity is gained no one even now knows with precision. A few years ago it was supposed that in the course of each of these illnesses something was removed from the body, in the absence of which the contagious germs could not again develop. The more modern view is that in each of the self-protective contagious illnesses an antidote is formed in the course of the development of the tens of millions of germs which cause the illness, and that the antidote remains, and is the protective agent against future attacks (*vide* Art. "Immunity"). The antidote has in fact been produced by the development of the germs, and it is owing to its presence that the illness in question comes to an end. The antidote is probably chemical in nature. It is certain that the poisons of many contagious diseases can be grown of varying strengths; they can by one method be made more virulent, and by another less so. There is a large amount of evidence in support of Jenner's original view that small-pox and cow-pox both come from the same poison; human small-pox being probably a very virulent development of a milder disease common to several animals. Several good observers have succeeded, though not without difficulty, in inoculating calves with human small-pox, and in getting, after a few removes, vesicles which yield lymph that protects from small-pox. The opponents of vaccination constantly dwell upon the supposed absurdity of preventing one disease by the induction of another, and a quite different one. Their argument falls to the ground if an essential and close relationship has been proved to exist between human small-pox, cow-pox, and its analogue in the equine race known as horse-grease. In the early efforts to prove, experimentally, the pathological identity of these three diseases, the great majority of the results were entirely negative. Considering how much commoner cow-pox was a century ago than it is now, it is likely that the animals upon which the variolous inoculation was attempted were often immune, from having already had cow-pox. Basil Thiele of Kasan twice, in 1836 and in 1838, however succeeded in inoculating a cow with variolous matter, and in producing cow-pox; Ceely in 1839 did the same; also Badcock in 1840. In 1852 the American physicians Drs. Adams and Putnam again succeeded, and the vaccine lymph thus obtained was extensively used in Boston and its neighbourhood. In 1865 a Commission, appointed by the Society of Medical Sciences at Lyons, and presided over by Chauveau, seemed to arrive at results at variance with those of the earlier observers. In their experiments the inoculation of cows with variolous matter produced not a vesicle but a papule; this papule could not be produced in an animal which had had cow-pox, either naturally or artificially; also in an animal on which a papule from variolous matter had been developed cow-pox could not be induced. The lymph from the Lyons papule, when used on the human subject, induced not cow-pox but small-pox, and this result was seen even in a second remove. Somewhat earlier similar results were obtained by Martin of Boston, U.S.A., as a large number of persons "vaccinated" by him from vesicles raised on a cow's udder by inoculation of variolous lymph were nearly all attacked with small-pox, and three died.

In 1885, and again in 1892 Dr. Simpson produced lymph by inoculating calves with variolous lymph. It appears that success much more often follows when young calves are used rather than mature animals, and when the variolous lymph was taken not later than the fifth day of the rash.

In several cases the tendency of the lymph to produce a generalised eruption was seen only in the earlier removes from the human, and disappeared after passing the lymph several times through calves. "Surgeon-Major King in 1889, being then stationed at Madras, inoculated a young bull-calf with fifth-day small-pox lymph obtained from a child suffering from the disease. On the eighth day after the inoculation a crop of vesicles made their appearance not at points of insertion, but some little distance away; from the lymph obtained from these vesicles another calf was then inoculated. In this calf again secondary vesicles also formed at each point of insertion of the lymph. The lymph stock was carried on through three more generations in calves. The vesicular eruption being now in each instance strictly localised to the points of insertion. With lymph obtained from the fifth calf of the series a number of children were vaccinated successfully."[1] It appears probable that the apparently negative results in many of the earlier experiments were less negative than they were then supposed to be. The vaccine vesicle is not as a rule seen the first time variolous matter is introduced into a calf. In many instances it has appeared only in the fifth or sixth passage through calves. Dr. Copeman's own experiments go to confirm this view. Even in the calves which showed no vesicles, subsequent vaccination with vaccine lymph produced no effect, and the earlier calves in each series from direct variolous inoculation had papules without definite vesiculation. Dr. Copeman says:—

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[1] Copeman, *Vaccination*, p. 55.

> I have thus far obtained an undoubtedly successful result in one series only out of four attempts; but I have at any rate been able to satisfy myself that it is possible to variolate the calf, and, further, that the result obtained in the first instance may become greatly modified in the course of successive removes; and, again, that animals which have been thus treated are no longer susceptible to vaccination.

He adds:—[1]

> If it can, as I believe, be conclusively proved that small-pox lymph, by passing through the system of the calf, is so altered in character as to become deprived of its power of causing a generalised eruption, while inducing at the site of inoculation a vesicle indistinguishable from a typical vaccine vesicle; and, more important still, if it be shown that when transferred again to man it has by such treatment completely lost its former power to produce a general disease, it may be fairly asserted that cow-pox—or, rather, that the artificially inoculated form of the disease which we call vaccinia—is nothing more nor less than small-pox modified by transmission through the bovine animal.

It seems, therefore, to be all but proved that cow-pox is only much attenuated small-pox, and that the protection it gives is due to the manufacture within the system of the vaccinated person of the same antidote, the presence of which, after an attack of small-pox, brings the disease to an end and prevents, in the majority of persons, a second attack. It is, however, well known that in a small minority even the protection afforded by a previous attack of small-pox fails, and the disease is again taken. Louis XV. died of a second attack at the age of sixty-four, having had his first attack of the disease fifty years earlier. The German Vaccination Commission in 1884 considered that the proportion of second to first attacks was about 1 in 636 cases. It is, however, certain that the protection derived from vaccination does not last as long as the protection from the survived disease, the amount of antidote formed being even in efficient vaccination much less than in small-pox itself. The antidote may vary, too, in more than one way; it may be poor in quality and deficient in quantity. It is probable that it is formed round each vaccine vesicle, and, if so, there would be four times as much from four vesicles as there would be from one, and much more from a large vesicle than from a small one. The degree of protection from vaccination would, therefore, vary with the number and size of the vesicles, and with the length of time which has elapsed since the vaccination. It is highly probable, too, that even the chemical value, as we may call it, of the antidote is by no means uniform. We must not expect mathematical precision in what is fundamentally a vital process. The child after vaccination grows rapidly, and the amount of antidote which secured him complete protection at first may be insufficient when his body weight has changed from ten or twelve lb. to four stone or more. Presently a time comes when he can again take the disease, though he is so far protected that it is not severe enough even to disfigure, much less to kill him. Later on he is still less protected, and presently he has practically used up the influence of his infant vaccination.

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[1] Page 64.

The store of the antidote should be renewed by revaccination. It is impossible to say exactly when these stages from safety to danger are reached. The strength of the assailing poison varies no less than the strength of its antidote. Small-pox has always varied much in its degree of severity. Even in unvaccinated people it is sometimes quite a mild disease. In the Leicester epidemic 1892-93 the type of the disease for the most part was very mild. Of 357 cases 261 were quite mild; among them there was no death; there were 89 confluent cases, with 14 deaths; and only 7 malignant cases, with 7 deaths.

Jenner was mistaken when he said vaccination would be as lasting a protection against small-pox as a previous attack; and much of the discredit which has fallen upon vaccination is due to this error on his part. It is unfortunate that he did not realise that he was not in a position to know how long the protective influence of vaccination would last. It needed only twenty years to show that after even efficient vaccination a slow progress from safety towards danger is inevitable, and that revaccination at least once after childhood is necessary if protection is to be maintained. In spite, however, of the almost universal oblivion of this fact, the effect of vaccination during the past century has been very striking. If we ask for exact figures, each country must be studied separately; we must know what the law is as to vaccination, how the law is administered, and how far it is actually enforced or evaded. The conditions vary in each country.

England.—The first vaccination law in England was passed in 1840. It recommended vaccination, but left the parent free to adopt or to decline it. In 1853 vaccination was nominally made compulsory, and penalties were imposed for non-compliance with the law. Practically, however, these provisions were found to be very imperfect, and the obligation to be vaccinated was little more than nominal till paid vaccination officers were appointed. In 1867 power was given to Unions to appoint such officers, but in many Unions the power was not exercised. In 1870 nearly half of the Unions were reported not to have appointed vaccination officers. In 1871 the Act of 1867 was amended, by making the appointment of paid vaccination officers compulsory in all Unions, and by improving the methods of registering vaccinations. In 1898 "the tremendous experiment" (as Lord Lister called it in the debate in the House of Lords) was made of practically leaving infant vaccination to the discretion of the father.

The whole effect of the Act of 1898 will be considered later. Omitting it for the moment it may be said that the number of deaths from small-pox in England steadily declined with each of the improvements in the law enforcing vaccination. Instead of 2000 to 4000 per million as in the eighteenth century, we had, during optional vaccination (1840-53), an average death-rate of 417 per million. With enjoined vaccination, from 1854 to 1871, there was a rate of 154 per million; and with enforced vaccination the rate was again reduced to 99. During the ten years 1889 to 1898 the mortality rate per million averaged 10 only. In London Dr. Farr's estimate of the annual small-pox mortality at the end of the eighteenth century was 5020 per million; under enforced vaccination this has been reduced to an average of 178 per million for the eighteen years ending 1890.

In considering these figures we must bear in mind that though a compulsory law does much, it fails to compel in a minority of cases, and that when we speak of compulsion it is likely that in every community there will be a considerable number of people whose parents have succeeded in evading the law as to infant vaccination. Moreover, in England, there is no law enforcing revaccination, and the large majority of adults have not been revaccinated, so that in the presence of an epidemic many of those vaccinated in infancy prove to be again liable to take the infection. The number of persons in this position will vary with the amount of public feeling for or against vaccination, and with the care taken to devise methods by which indirect pressure shall be brought to bear in favour of vaccination. It is also important to remember that even the low rate of mortality in England in recent years represents a considerable annual aggregate of deaths, and about seven times as many cases of illness; a death-rate of only 10 per million sounds low, but it comes to over 300 deaths a year, and it implies about 2000 cases of illness which might be prevented. It will be seen in studying the facts as to vaccination in the German Empire how far England is from the highest measure of success in the prevention of small-pox.

In tabular form we have :—

For all England.	Deaths.
18th century rate, a minimum of	2000 per million.
1801, Vaccination introduced and largely adopted,	No precise figures.
1840 to 1853, Optional vaccination, average,	417 per million.
1854, Enjoined vaccination, average,	154 „ „
1871, Compulsory vaccination, average,	99 „ „
1889 to 1899, Better administration of the Vaccination Act, aided by isolation,	10 „ „

For London alone we have Dr. Farr's estimate of the small-pox mortality at the end of the eighteenth century as 5020 per million. Under enforced vaccination, in spite of many evasions of the law, and of the great epidemic of 1871-72, the average mortality of the eighteen years ending in 1890 was 178 per million. The gradual steps of the decline are thus given by Dr. Farr :—

1838-53,	average mortality,	514 per million.
1854-71,	„ „	388 „ „
1872-90,	„ „	178 „ „

In Scotland the rate of mortality from small-pox in the last eighteen years of the eighteenth century is believed to have been at least 4700 per million of population. From 1853 to 1864 vaccination was optional, the mortality rate was 340 per million. From 1865 to 1889 it was compulsory, and the rate came down to 80 per million. For the five years 1893-97 it has averaged 12. In Ireland during the same five years the rate has averaged 10 per million :—

18th century rate	4700 per million.
1853-64, vaccination optional,	340 „ „
1865-89, „ compulsory,	80 „ „
1893-97, better administration of Vaccination Act,	12 „ „
Ireland, 1893-97,	10 „ „

In France there was, up to February 1902, no compulsory vaccination law, but vaccination was indirectly encouraged by the Government. No official post could be taken without producing a certificate of vaccination. Vaccination has been enforced for the French army since the year 1888. No statistics exist as to the total mortality from small-pox in the whole of France. The small-pox mortality of the large towns is known, and in these, with a population in 1892 of 8,000,000, 5670 lives were lost in the five years 1889-98, while in the same years Germany lost only 572 out of a population of 50,000,000. There have been no means of ascertaining the mortality from small-pox in the rural districts of France. The women and children and all defective male persons excused from service in the army have not been protected by any legal enactments in support of vaccination. Small-pox has been continually present in France, especially in the southern Departments. It is likely that the loss of life from small-pox among women and children has been an important factor in the absence of growth of population in France. In February 1902, however, France adopted compulsory vaccination in infancy, and revaccination in the eleventh and twenty-first years of life. If this law is properly administered the condition of France with regard to small-pox ought speedily to be much improved.

In Sweden, where registration of deaths dates from 1774, instead of as in England from 1837, the average for twenty-seven years before 1800 was 2008 deaths per million. With permissive vaccination the fifteen years' average from 1801 to 1815 was 631. With compulsory vaccination from 1816 to 1885 the seventy years' average was 173 per million; with increased care in enforcing the law the rate during the four years 1893-96 was reduced to an average of 2·1.

In tabular form:—

18th century, small-pox mortality,	2008 per million.
1801-15, permissive vaccination,	631 „ „
1816-85, compulsory vaccination,	173 „ „
1893-96, improvement of administration of vaccination law,	2·1 „ „

Denmark.—At Copenhagen the population and the small-pox deaths have been recorded year by year since 1750. In the years 1750 to 1800 the average small-pox mortality rate was 3567 per million. Vaccination was introduced in 1801, and it was extensively practised. It was permissive only, but the mortality rate fell to 660. The law for compulsory vaccination came into effect in 1810, and the average death-rate for the next sixty years was 130. For the years 1893-97 the average mortality from small-pox has been ·5 per million for the whole of Denmark.

In Prussia vaccination has been compulsory upon all recruits for the army since 1831. There was no law for the compulsory vaccination of infants till the year 1874. It was then enacted that every child should be vaccinated before the end of the year next after the year of its birth, so that in many cases it happened that the child was nearly two years old before it was vaccinated. Revaccination was at the same time made compulsory upon all children of school age; and on joining the army the recruits were again revaccinated. Therefore to argue that Prussia or any other kingdom of Germany had compulsory vaccination generally enforced before 1874 is worse than stupid; it is a deliberate untruth. But the statement is still made from time to time in this country. From the date of the Act of 1874 small-pox has been extremely rare in the Prussian army. The small-pox mortality in the Prussian nation from 1865 to the end of 1874 averaged 755·4 per million; after the law of 1874 the average for the next ten years was 22·2. The great epidemic of 1871-72 no doubt brought up the mortality very considerably in the earlier decade, but even in non-epidemic years it was high, *e.g.* in 1865, 1866, 1867 it was respectively 438, 620, 432, while in 1877, 1878, 1879 it was reduced to 3, 7, and 13 respectively. There was a slight increase in 1880, 1881, and 1882, when for two years the rate was 36, but how small is this compared with the rates of the previous decade when twice only was it under 150. The exact figures are shown in the following table:—

Prussia—Before the Law of 1874

Year.	Deaths per Million of Population.	Year.	Deaths per Million of Population.
1865	438	1870	175
1866	620	1871	2432
1867	432	1872	2624
1868	188	1873	356
1869	194		

After the Law of 1874

Year.	Deaths per Million of Population.	Year.	Deaths per Million of Population.
1874	95	1880	26
1875	36	1881	36
1876	31	1882	36
1877	3	1883	20
1878	7	1884	14
1879	13		

The next decade of Prussian statistics shows a still further diminution in the mortality rate. Their splendid vaccination system, with twenty-five State Institutions for supplying calf-lymph, was not brought to its present high standard at once after the law was passed, it had to be created and to be gradually developed. The ten years, 1885 to 1894, show these rates :—

Prussia.

Year.	Mortality per Million of Population.	Year.	Mortality per Million of Population.
1885	14	1890	1·2
1886	5	1891	1·2
1887	5	1892	3
1888	3	1893	4·4
1889	5	1894	2·5

In the Prussian army there have been but two deaths from small-pox since the year 1875, one in 1884, one in 1898. The first was that of a reservist who had been twice unsuccessfully vaccinated in the army.[1]

Statistics for all Germany do not begin till 1886. Steady improvement is shown in the small-pox mortality rates per million, year by year, from 1886 to 1899, *i.e.* for fourteen years.

Year.	Small-pox Mortality Rates per Million.	Year.	Small-pox Mortality Rates per Million.
1886	4·2	1893	3·1
1887	3·5	1894	1·7
1888	2·3	1895	0·5
1889	4·1	1896	0·2
1890	1·2	1897	0·1
1891	1	1898	0·3
1892	2·1	1899	0·5

In the entire German Empire the average rate of small-pox mortality in the ten years, 1890 to 1899, was 1·07 per million, *i.e.* about one-tenth of the English rate in the same years, and this in a population surrounded with more or less unvaccinated neighbours.

Is it possible to doubt, after studying these figures, the value of a strict law both for vaccination and revaccination, and of ceaseless endeavour after perfection in the administration of the law?

Attempts are made by the opponents of vaccination to attribute the remarkable results of the law of 1874, and of the administrative improvements which have been gradually made in Prussia since that date, to stricter isolation which they say began in 1883. No reasonable person doubts the value of the isolation of small-pox patients. Professor Koch spoke highly of it before the German Vaccination Commission of 1884, but the official Report of the Commission, issued in 1885, mentions no new law of isolation, nor does the volume on vaccination, issued by the Imperial Health Office, Berlin, in 1896. It is, however, possible that some administrative improvements were made in favour of stricter isolation without any change in the law. Of this, however, no evidence can be quoted. When Germans are asked how isolation is carried out in their country in cases of small-pox, the answer is to the effect that they do not know, as there is no small-pox in Germany. This is not strictly correct, but it shows that in Germany epidemics are not so much arrested by isolation as prevented by efficient revaccination.

The Report of the German Commission on Vaccination gives the following table, showing the relative mortality from small-pox per 100,000 population over nine years, between Dresden with compulsory vaccination and revaccination, and Prague with no compulsory vaccination.

Year.	Dresden.	Prague.
1875	2·5	11
1876	0·5	78
1877	0·9	395
1878	0·0	86
1879	1·8	84
1880	3·6	290
1881	2·6	64
1882	1·3	57
1883	0·8	224

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[1] V. r. *Small-pox in England and other Countries*, p. 35. E. J. Edwardes, M.D., etc.

In Austria vaccination is recommended, but it is not compulsory. Since 1891 sharp supervision has been exercised in its support, especially as to vaccination or revaccination at school age. The average mortality for the five years 1877 to 1881 was 619 per million; for the four years 1893 to 1897, with increased pressure in favour of vaccination, the average mortality was reduced to 99 per million, not good in itself, but much better than before. To reduce the mortality to the lowest possible the vaccination law should be compulsory. The methods of its supervision carefully organised, and revaccination in early adult life made obligatory.

In Switzerland, some of the cantons have no compulsory infant vaccination. The towns of Basle and Zurich are in these cantons. Much indirect pressure in favour of vaccination is, however, given in the absence of a compulsory law, and in some districts from 60 to 78 per cent of the children are vaccinated. There is nowhere in Switzerland any compulsory revaccination. Grouping the cantons in which infant vaccination is the law into one group, and those in which it is not the law into another, the small-pox death-rates *per million* living are as follows:—

Year.	Cantons with Compulsory Vaccination.	Cantons without Compulsory Vaccination.
1880	1·5	35
1881	4·5	23
1882	0	16
1883	0	13
1884	1·4	15
1885	105·6	165
1886	0	14
1887	0	12
1888	0	15
1889	0	13
1890	0	29
1891	0	15
1892	8·9	89

In Italy there is now compulsory infant vaccination and revaccination at school age. The laws date from 1888 and 1891. The actual number of small-pox deaths in 1889, before the new law had taken effect, was 13,416; in 1898 it had fallen to 420. This is in a population of about 30 millions. The mortality rate per annum for the five years 1893 to 1897, is much higher, amounting, where averaged, to nearly 73 per million. The actual deaths from 1893 to 1898 were these:—

Year.	Actual Deaths.	Year.	Actual Deaths.
1893	2638	1896	2033
1894	2606	1897	1003
1895	2998	1898	420

The Italian figures supply a further commentary on the statement that success as to vaccination laws must depend to an enormous extent on the degree of perfection attained in their administration. The mortality in Italy even after the laws of 1888 and 1891 was very high; gradual improvements in administration have brought it down, under the same law, to 420.

In Hungary the vaccination law dates from 1887, in which year there was a small-pox mortality of 18,063. In 1898 this was reduced to 1656. For the five years 1893-97 the average rate per million was 134 = 2412 deaths each year. There is still evidently great room for administrative improvements in carrying out the law in Hungary.

In the Netherlands there is no compulsory infant vaccination, but vaccination certificates are required from all pupils and teachers in schools. A considerable proportion of the infant population is vaccinated every year in spite of the absence of a compulsory law. The small-pox mortality rate per million in the five years 1893-97 was 38·7.

In Spain there is no law enforcing vaccination, and for the four years 1893-96 the mortality rate per million was 563·4.

In Russia there is also no law enforcing vaccination, and for the five years 1893-97 the mortality rate in a population (including Asiatic Russia) of 119 millions was 463·2; *i.e.* in each year the deaths from small-pox are believed to have been over 55,000.

The following tables show at a glance the varying rates of small-pox mortality per million of population under varying conditions as to vaccination and revaccination. The effect of legal pressure in support of vaccination is seen by taking the small-pox mortality in various countries and decades, and contrasting it in each case with the mortality in Sweden before the introduction of vaccination, which is accurately known :—

Before Vaccination per Million of Population.	Vaccination not Obligatory by Law, but Encouraged.		Vaccination (nominally) Obligatory by Law.		Vaccination Obligatory under Penalties Charged only.	Revaccination of all School Children.	Thrice Vaccination.
Sweden, 1792-1801.	Prussia, 1860-69.	Austria, 1881-90.	Sweden, 1859-68.	England, 1857-66.	England, 1889-98.	Germany, 1890-99.	Prussian Army, 1875-99.
880	190	814	388	206	·8	1·2	Two deaths in twenty-five years. One death refers to a reservist twice unsuccessfully vaccinated.
944	302	948	183	335	0·6	1·0	
1758	211	592	49	197	1·7	2·1	
2956	338	508	37	140	14·7	3·1	
1963	463	601	76	66	49·3	1·7	
751	438	382	182	81	27·3	0·5	
585	620	447	325	293	7·3	0·2	
1609	432	645	293	373	17·6	0·1	
5126	188	557	253	309	0·8	0·3	
2566	194	249	342	144	8·1	0·5	
Average in the 10 years } 1914	337	574	213	214	13	1	

In studying this table it must be remembered that Germany is surrounded by populations (Russia, Holland, Austria, France) which have had till lately no compulsory general vaccination law, and that most of the cases in Germany occur on the frontiers.

Further evidence is obtained from the facts tabulated thus :—

Recent Death-rates from Small-pox per Million Living, for the Ten Years 1890-99 *in Four Countries*

	Sweden.	Scotland.	Belgium.	Netherlands.
1890	0·2	0	105	not given
1891	0·2	0	211	2
1892	0·8	3	408	10
1893	5·0	17	336	41
1894	3·5	32	85	130
1895	0	11	46	16
1896	0	0·4	20	7
1897	0	2	21	not given
1898	0·2	0·4	24	1
1899	0	0·2	38	not given

Average Deaths from Small-pox in various Places in the same Five Years 1893-97, *per Million of Population*

	French Towns.	Germany.	Netherlands.	Austria.	Russia.
1893-97	90	1·1	39	99	4 63[1]

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[1] The actual number of deaths from small-pox in the Russian empire, including Asiatic Russia, in the five years quoted, was 275,502.

Germany, Hungary, Italy, Roumania, Japan, and, quite recently, France, all now have compulsory revaccination. Time and patient effort to improve administration will be required everywhere to reach results equal to those seen in Germany.

In the survey now made of the effect of legal compulsion as regards vaccination and revaccination in European countries the evidence all points the same way, viz. that efficient vaccination and revaccination greatly diminish the number of deaths from small-pox, and that a compulsory law for vaccination and revaccination is necessary if a nation is to be free from a large small-pox mortality. It is, however, necessary to bear well in mind that it is not the existence of a law in favour of vaccination that protects, but the fact that the individual members of the community have obeyed the law. It is misleading to speak of places as being well vaccinated. The place is not the unit, every person in each place is protected or not according to his own vaccination and revaccination. Where there is a minority of people who are not protected, they are liable to take the contagion of small-pox *if exposed to it*, no matter how well protected their neighbours may be. They are of course much more liable to meet the contagion if they are surrounded by people who are able to receive and to communicate it, but this is all they gain by the protected condition of their neighbours. If and when they do meet the contagion they are pretty certain to take it.

One of the most important proofs of the value of vaccination has been the change of the age at which small-pox deaths mostly occur now as compared with the age at which they chiefly occurred in pre-Jennerian times.

It is certain that before the practice of vaccination, small-pox was the most dreaded and the most fatal of all the diseases of children. In the seventeenth and eighteenth centuries it was said by some authorities to account for half the total mortality of children under ten years of age. Among other proofs which might be quoted in support of this statement the following may be given. In Chester in 1774 all the 202 deaths in an epidemic were those of children under 10, and 50 of the deaths were in children under one year of age. In Warrington in 1778, all the deaths were those of young children. In Kilmarnock, of 622 deaths which occurred in several epidemics, the ages of 9 are not given, but all the rest were under 10 years of age. The burial registers of St. Cuthbert's and Buccleuch Street, Edinburgh, show that during the years 1764-83 of every 1000 deaths from small-pox, 993 were those of children under 10. The small-pox deaths at the Hague for fifteen years numbered 7473; of these 6045 were of children under 5.

In the Final Report the Commissioners say that "in all records of epidemics where the ages are given, the mortality was mainly among infants." In Berlin from 1758 to 1774 there were 6705 small-pox deaths, of these 5876 were of children under 5, = 87 per cent, and of children under 10 there were 6618, = 99 per cent (14). In Manchester 1769-74, of 589 small-pox deaths 559 = 94 per cent were of children under 5. In 1796 in Berlin of 817 deaths only 1 was over 16 years of age (15).

The opponents of vaccination are fond of saying that small-pox was a trifling illness "a mere disease of children." The records now quoted scarcely justify the "mere" or the "trifling." The truth is, it was a fearful scourge, and a terror to all parents.

The explanation of the very great mortality of young children as compared with adults is to be found in the rapidity with which epidemics of small-pox followed each other. In each epidemic those who died were probably about one-seventh of those attacked. The six-sevenths recovered and were immune for many years, often for life. They had purchased immunity by suffering, possibly by loss of sight, almost always by permanent disfigurement. In isolated places and where epidemics came at long intervals, many adults died, because there were in this case fewer adults who were protected by having had the disease in childhood. Since vaccination has been employed, and since it has been practised mainly in early infancy, the mortality rates, as between infancy and adult life, have completely changed. Children are now the protected class, and their protection is stronger the younger they are, because they are then nearer to their vaccination. It would be difficult to even suggest any possible cause other than vaccination for this striking change in the age incidence of the mortality from small-pox.

The Sheffield epidemic 1887-88 afforded a good illustration of the value of vaccination in early life. There were in Sheffield 33,393 vaccinated children under five years of age. Of these 121 (= 0·36 per cent) took small-pox, and one child died from it = 0·003 per cent of the total number. Of unvaccinated children under five there were 1981, of whom 128 (6·5 per cent) took the disease and 66 died of it (= 3·3 per cent of the whole number of unvaccinated children, and 51 per cent of the children attacked). The table of the Sheffield mortality in age classes is instructive :—

Sheffield Epidemic—Age Classes

1	2	3	4	5	6	7	8
Ages.[1]	Population at that Age.	Cases.	Per Cent.	Deaths.	Per Cent.	Fatality, *i.e.*, Rate of Death to Attack.	Deaths per 100,000 in each Age Class.
			Vaccinated.				
Under 5	33,393	121	0·36	1	0·003	0·8	3
5 to 10	34,843	232	0·67	5	0·014	2	14
10 to 15	32,965	629	1·9	11	0·03	1·7	30
15 to 20	27,111	979	3·6	19	0·07	2	70
20 to 30	44,788	1267	2·8	69	0·15	5·4	150
Above 30	92,041	899	0·97	95	0·1	10·4	100
			Unvaccinated.				
Under 5	1,981	128	6·5	66	3·3	51·	3,300
5 to 10	278	100	36	34	12·2	34·	12,200
10 to 15	235	91	38·7	32	13·6	35·	13,600
15 to 20	282	84	29·8	53	18·8	63·	18,800
20 to 30	884	98	10·6	61	6·9	62·	6,900
Above 30	2,028	49	2·4	28	1·4	57·	1,400

The fourth column in this table shows the difference of liability in the two classes to take the infection at varying ages. The fifth column gives the actual number of deaths at each age. It shows how the protection of vaccination wears out progressively with age. The sixth column shows the percentage of deaths to the number of inhabitants; and the seventh the percentage of deaths to attacks, or the "fatality rate," in the two classes, and at the varying ages.

The Sheffield figures are often quoted by the opponents of vaccination. They say Sheffield was a well-vaccinated place, and yet small-pox caused 474 deaths, of which 200 were of vaccinated people. When analysed the figures show clearly how great the protection of vaccination is in early life, and how necessary revaccination is to renew the protection for later life.

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[1] Excluding children under three months, the age at which they should be vaccinated.

The study of the proportion of deaths between the ages 0 to 10 at different places also gives evidence which is worth considering, vaccination being much more practised in some places than in others. Taking six places where recent epidemics have been carefully studied, we find that the percentage of mortality in cases under ten years of age varies very much, and that where vaccination has been to a great extent in abeyance the infant mortality from small-pox is the highest. The Commission gives the following table in their Final Report, p. 50:—

	Percentage of the Total Small-pox deaths borne by those between the age 0-10
Warrington	22·5
Sheffield	25·6
London	36·8
Dewsbury	51·8
Gloucester	64·5
Leicester	66·6

In London there had been a considerable falling off in the amount of vaccination for some time before the epidemic of 1892. In Warrington and Sheffield the law had been fairly well obeyed. At Dewsbury vaccination had been greatly neglected. At Leicester vaccination had been largely abandoned for some time before the epidemic. At Gloucester vaccination fell into almost complete disuse for some years before its epidemic. There is here no question as to whether children were vaccinated or not vaccinated. The total deaths of children under ten were three times as many where vaccination had been in abeyance as it was in places where the law was for the most part complied with.

The Commissioners conclude by saying:—"Apart from the difference in the extent of vaccination, no cause has been suggested at all adequate to account for the variations in the age incidence of fatal small-pox upon which we have been dwelling. . . . If improved sanitation were the cause of the diminished mortality of children in proportion to that borne by those of older years, it is quite impossible to understand how its effect should have varied so greatly in these different towns, and why in Gloucester and Leicester the mortality from the disease should have been so largely among children, approaching in that respect the experience of the epoch preceding vaccination." In the same six towns the fatality in the vaccinated was 2·8 per cent, while in unvaccinated children it was 30·3 per cent.

The incidence of small-pox mortality on different classes of the community also furnishes proof of the protective influence of vaccination. Doctors, nurses, hospital attendants, all show similar results. But for vaccination doctors would certainly be far more likely to contract small-pox than other people. As, however, they almost invariably protect themselves by vaccination and revaccination, their mortality rate is only as 1 to 5·6 in the whole community. The risk they run of taking contagious fevers, for which no protection is possible, is shown by the fact that their mortality from this cause is 3·68 times as high as that of the general public. It has always to be remembered that vaccination takes a certain time to develop its protective influence. The incubation period of small-pox is usually twelve days, occasionally more. The initial illness begins twelve or more days after the poison has been received into the system. Vaccination takes nine days to develop its influence. The attack of small-pox is not prevented unless the antidote created by the vaccine vesicles has had its necessary nine days before the fever of small-pox begins. Dr. Gayton reported that at the small-pox hospital in 1871-77 out of 366 people employed all but one were revaccinated. The one unvaccinated person took it, and at once. The same thing was repeated later. Dr. Marson, in thirty-six years, had no nurse or servant attacked. Probably some of the nurses and servants in small-pox hospitals have usually had the disease itself, and are protected by their previous illness, but this only refers to a small proportion of the whole staff, and it does not destroy the weight of evidence afforded in support of vaccination. In the recent epidemic (London, 1902) there were in the Mile End Infirmary forty-three nurses or attendants when small-pox was accidentally brought into the wards. Thirty-one of the number had been revaccinated at various dates up to two years before the outbreak. Four were revaccinated, two unsuccessfully. None of these thirty-five contracted small-pox. Of the remaining eight, one was away on sick leave, leaving seven, who all suffered from small-pox. Of these three were not revaccinated, and four all sickened with small-pox before their vaccination had had time to protect them, viz., two on the second, one on the third, and one on the sixth day after vaccination. None after nine days. Thus these four cases were incubating small-pox at the time they were vaccinated, and though they might be classed as vaccinated, they were not really under its influence. It is certain that none of the nurses who were revaccinated before exposure to infection contracted the disease, and that all who suffered were either unvaccinated or revaccinated after they had received the contagion. Dr. Hope in his Report upon the epidemic of small-pox in Liverpool (1902) says "Nurses, doctors, laundrymaids, and servants at the small-pox hospital in Liverpool are rendered immune from small-pox by efficient vaccination. No one can doubt that if the general public were as efficiently vaccinated as the hospital staff they would be equally immune from small-pox."[1]

Experience of this kind could be quoted from every small-pox hospital. Where vaccination has been evaded, or unsuccessful, or postponed even for a few days, the infection is taken; not where it has been efficiently performed before exposure to infection.

Among the Post-Office staff in London averaging, at that time, 10,504 persons there was not a single death from small-pox in the ten years 1871 1880 though this included the great epidemic of 1871. During the ten years 1891 to 1900, the Post-Office service of the United Kingdom employed 692,852 persons. Among them, in the ten years there were two deaths from small-pox.[2] In the recent epidemic (1902) one Post Office servant died of small-pox at Bury St. Edmunds. He had refused to be revaccinated on his appointment, and by some administrative defect he had been allowed to evade the regulation.

In the Navy revaccination has been the rule since 1864. From 1895 to 1900 inclusive there have been in all nine deaths from small-pox, six of these have occurred off China, one in India, and two in the irregular forces. Probably all were due to evasion of the regulations.

In the Army revaccination has been the rule since 1858. In 1899 the total Force was 201,004: (India, 67,697; Home, 99,832: Egypt, 3,959). There were two small-pox deaths, one in India, and one in the non-European troops in West Africa. In India, Egypt, and West Africa there is always a large amount of small-pox in the native populations. But for vaccination and revaccination probably no European country could hold India, the loss of life in the Army from small-pox would be so enormous. In the Home Force for 21 years up to 1899 there was an annual death-rate from small-pox of ·076 per 10,000. In the colonies the rate was ·038 per 10,000, in India it was nearly ·7 per 10,000; in Egypt there had been twenty-five deaths in the British troops in the course of thirteen years.

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[1] Report of the Medical Officer of Health, Liverpool, 1902.

[2] Official letter from Postmaster-General to Dr. Edwards.

The evidence in the support of vaccination being so overpoweringly strong the questions arise: How can any one refuse to accept it? What is the secret of the resistance to vaccination? The first point to notice, in trying to answer these questions, is that the number of people practically acquainted with small-pox who do not believe in the protective influence of vaccination is so small as to be in effect non-existent. No one has ever heard of an anti-vaccinist who had held a post at a small-pox hospital, or had had large experience of small-pox in any other way. The anti-vaccinist as a rule has only studied small-pox from afar, in the safe seclusion of the British Museum Reading Room or of his own study. In the second line of the party stands the impenetrable body of cranks, the people who cannot accept evidence, and who cannot distinguish between small evils and great ones. To them a sore arm for a few days seems as important an evil as small-pox itself. Behind the cranks there is the great mass of uneducated people who are against vaccination because it gives them a little trouble, some restless nights, and because they do not realise what small-pox really is. They have heard of or seen cases in which vaccination has done harm. It is easy to sympathise with this group of objectors. It must be admitted that a large part of the opposition to small-pox is based upon evil results which have sometimes followed the operation, and which have been due for the most part not to the compulsory law but to its faulty administration. Many of the deaths ascribed to vaccination have probably had nothing whatever to do with it; but on the other hand we have to recognise that infants of three months old are very sensitive creatures, and that as an undigested mass of casein or other food in the stomach may cause a convulsion in one child, an inflamed arm may possibly do the same in another, and that in a third both conditions may exist, and that they may combine to do the mischief.

Eruptions and Injuries after Vaccination.—Vaccination is occasionally followed by eruptions. Some of these follow a pure vaccine inoculation, and they may occur immediately after vaccination or soon after the development of the vesicles. Many of them are probably due to reflex nervous influences, others to secondary local inoculations, or to absorption of virus from the developed vesicles. Bearing in mind the powerful influence that vaccination exerts over the organism for a series of years, it is not remarkable that it should occasionally disturb the nutrition of the skin and other organs, and interfere for a time with the vital chemistry of the individual. On the other hand, many cases have been recorded in which the constitutional change started by vaccination has appeared to be beneficial, as for instance in the sudden disappearance of an extensive eczema after vaccination. Few of the eruptions due to a pure vaccine inoculation need be regarded with anxiety. They are rare, and for the most part trivial in character. Other eruptions are due to a mixed infection either at the time of vaccination or subsequent to it, but through the wounds. Much may be done to prevent eruptions of this class by guarding the vaccination wounds with care, and by using only lymph from which extraneous germs have been removed. Even as regards vesicles which may be called normal, considerable variety in the rate of healing and in the degree of the surrounding inflammation of the skin may be seen. This variety probably depends more on the vital condition of the patient than upon anything else.

Vaccination vesicles should be well and soundly healed before the end of the third week, but the power and rate of healing vary much in different individuals. Generalised vaccinia usually results from auto-inoculation. Dr. Acland has recorded a remarkable case which resulted in death. It may depend upon an abnormal absence of vaccinal immunity. "It is certain that during the first week after vaccination a person may be readily revaccinated or may contract small-pox, for it does not appear that any considerable degree of immunity is established till after the pocks have reached maturity. Immunity probably reaches its maximum about the fourth week after vaccination, but the standard of resistance varies in each individual, and probably also with the dose and activity of the virus."[1] In the fatal case above alluded to pocks continued to form for thirty days or more, showing the absence of immunity. The same condition may have been the explanation of the case in the Gloucester epidemic, in which a child developed fatal small-pox twelve days after being successfully vaccinated. The problems of infection and immunity are vital, not mathematical, and they manifest from time to time the variations proper to all vital processes. Another case illustrating the same truth has been recorded by Dr. Clifford Allbutt, in which a woman under forty years of age had had small-pox in a mild form three times, and had also been three times successfully vaccinated. Vaccinia hæmorrhagica and vaccinia gangrenosa are two conditions which apparently depend upon constitutional defects in the individual rather than upon the presence of any pathogenic organism in the vaccine lymph. Eczema and other inflammations of the skin are extremely common in early infancy, and the slight irritation resulting from even normal vaccination may be sufficient in some children to produce the condition which underlies the skin affection. With regard to congenital syphilis it should be borne in mind that vaccination may be quite normal in a child who will presently show indubitable signs of inherited taint; it is possible, too, that in such a child the temporary disturbance of health due to vaccination may precipitate the manifestations of inherited disease. In such a case careful inquiry into the history of the symptoms, their order and chronology, will almost always show the real relationship between the two sets of facts. It is obviously of the greatest importance to distinguish between syphilis which has been communicated by vaccination and the results of vaccination in a syphilitic child. It should be remembered that, both in England and Scotland, inherited syphilis kills a large proportion of its victims before the age at which vaccination is enjoined; also that when vaccination was practically in abeyance in Leicester the number of deaths from infantile syphilis showed an increase of 69 per cent as compared with an increase of 24·7 per cent from the same cause over the whole of England and Wales, where vaccination was much more common. It would, of course, be absurd to suggest that vaccination prevents the development of inherited disease, but these figures show that such disease is as common and as fatal in the unvaccinated as in the vaccinated portions of the community. It is true that a very small number of cases have occurred in which the disease has been conveyed through vaccination. The fact that they were infinitely rare did not carry much weight in the minds of anxious mothers. The other fact, that syphilis thus inoculated into the skin of a previously healthy child would run a course entirely unlike the inherited disease, the lay public were not able to appreciate, and the tendency was to connect every manifestation of inherited syphilis with the vaccination which had perhaps preceded it by a week or two. It is easy to understand how ready the father or mother would be to throw the blame of such disease on the vaccination, and also how willing sympathetic and courteous neighbours would be to accept this explanation. It would be unreasonable to expect in parents or neighbours the knowledge as to the prevalence of inherited specific disease that is learnt in the out-patient department of every hospital where children are received. The truth is that vaccino-syphilis is and has ever been almost infinitely rare; that the inherited disease is extremely common; and that, as a rule, this form of disease is plainly to be recognised before the child arrives at the vaccination age. Similarly with regard to deaths from erysipelas, the infant mortality from this cause in Leicester during the years 1883-1887, when there was very little vaccination, showed an increase of 41·5 per cent as contrasted with a diminution of 16·7 per cent over the whole of England and Wales. Had vaccination really been the cause of many cases of erysipelas, Leicester would surely have been able to show a better result than this.

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[1] *Vaccinia in Man*, J. D. Acland, M.D., p. 29.

The same considerations apply to lupus and tubercular infection as supposed results of vaccination. The fact that lupus has in a few cases begun in a vaccination wound or scar does not prove that the virus was introduced at the time of vaccination. Lupus is not very uncommon, and it is often started in a trivial wound of the skin with no possible connection with vaccination. Unvaccinated Leicester was no more free from deaths due to tubercular disease of the brain and abdominal organs than was fairly well-vaccinated England. So also as to the supposed connection between vaccination and leprosy or cancer. In the case of leprosy, where the virus is located mainly in the skin, it may possibly be that it could be communicated through vaccination if this was carefully attempted, and if lymph were taken from vesicles raised on a portion of skin already infected with leprosy. Needless to say, this would in practice never be done, nor would lymph be taken from an individual who showed signs of leprosy in even very distant parts of the skin.

The really grave complications of vaccination arise in almost every instance from inflammatory or septic affections common to all wounds, unless most carefully guarded against. Serious injury from vaccination is almost unknown in well-cared-for infants. With cleanliness, suitable food, and care, any abnormal result from vaccination is exceptionally rare. Taking all classes together, the mortality resulting from vaccination accidents before the Act of 1898 was in England 1 in 14,000, in Scotland 1 in 38,000, and in Germany 1 in 100,000. Every vaccination ought to involve four wounds of the skin. Till within a very short time a large number of vaccinators left these wounds quite unprotected. The wonder is not that some of the wounds were poisoned, but that so few were. The Act of 1898 did good by insisting upon much more care being taken of vaccination wounds, and by enjoining regulations for keeping them aseptic. How far these regulations can be observed in the crowded and often dirty homes of the poor may be questioned; but it is something to have urged the need of greater care in the direction of asepsis upon the vaccinators themselves, and through them upon the mothers. It may be hoped that the lesson will in time be taken to heart even more than has been done at present, and that a very large reduction in the number of vaccination accidents will be the result. What can be done in Germany is not impossible in England.

THE EFFECT OF THE VACCINATION ACT OF 1898.—The Act of 1898 did great service to vaccination by introducing the use of glycerinated calf-lymph instead of humanised lymph. As calves cannot take the syphilitic poison there is absolutely no possibility of its being conveyed from them, and this particular danger, rare as it was, no longer exists when calf-lymph is used. The risk of tuberculosis is not quite so completely removed. Calves can be tuberculous, though they are less prone to the disease in early life than they are later. But every calf used for the manufacture of calf-lymph is put to death and thoroughly examined before the lymph is distributed. In the rare cases in which any evidence of tubercular infection is found the lymph from that source is immediately destroyed. But even if this were not always done, by the thorough and intimate admixture of glycerine with the lymph, and by storing the mixture for a considerable time under conditions which prevent the access of light and air, Dr. Copeman believes that all foreign or extraneous organisms in the lymph, including the tubercle bacillus, are gradually destroyed, and the vaccine organism only left.

The Act of 1898 further abolished the vaccination stations, and ordered the public vaccinator to vaccinate the child at home and to inspect the result of the operation there, on the eighth day. It permitted the father to obtain a certificate of exemption for his child on application to a magistrate as a "conscientious objector" to vaccination.

How far has the Act of 1898 been on the whole a success or the reverse? The "conscientious objector" clause was passed in the interests of vaccination. The framers of the Act believed that the final result of allowing parents to ask for exemption from the duty of having their children vaccinated would be to diminish resistance to the law. They required the father to appear before a magistrate and to declare that he "conscientiously disapproved" of vaccination. This was intended to involve a certain amount of trouble. While permitting conscientious objectors to get leave to disregard the law, many important practical improvements were made in the administration of vaccination. The use of glycerinated calf-lymph, the abolition of vaccinating stations, and the much greater care to keep the wounds aseptic, all told in support of vaccination; and it seems probable that these influences are producing an effect. Certainly in almost every union-county in England the number of children vaccinated in 1901 greatly exceeded the number in 1898. With but one exception—the North Riding of York—all the union-counties in the following table show increased numbers vaccinated in 1901; and in many cases, *e.g.*, in Bedford, Chester, Derby, Essex, Leicester, Lancaster, Nottingham, Stafford, and Warwick, the increase is very considerable—

Union-Counties of England.	Certificates of Successful Vaccination.			
	1898.	1899.	1900.	1901.
Bedford	325	1,830	1,456	1,579
Berks	4,121	4,864	4,397	5,325
Buckingham	1,896	3,904	3,029	3,179
Cambridge	3,332	4,598	4,298	4,385
Chester	16,891	19,518	19,382	18,430
Cumberland	4,601	6,094	7,333	6,986
Derby	4,477	9,459	7,903	8,027
Devon	11,012	11,008 - 4	13,413	12,835
Dorset	2,826	3,845	3,932	3,933
Durham	26,720	29,270	29,902	32,146
Essex	11,834	18,699	20,775	22,877
Gloucester	5,477	10,816	10,206	10,162
Hertford	2,950	4,333	4,601	4,770
Huntingdon	925	1,383	979	1,037
Kent	14,174	18,961	19,840	20,349
Lancaster	74,951	101,768	103,402	97,556
Leicester	769	3,150	3,478	3,265
Lincoln	5,780	9,253	9,939	9,925
London	63,326	86,514	86,591	111,958
Middlesex	9,283	15,003	15,953	20,624
Monmouth	6,092	7,595	7,661	8,144
Norfolk	5,963	8,277	9,161	8,934
Northampton	1,718	3,755	3,510	3,454
Northumberland	10,538	12,598	14,088	14,559
Nottingham	6,384	11,289	11,927	12,252
Oxford	2,907	4,303	4,055	3,479
Salop	4,826	6,089	6,006	6,100
Somerset	5,780	9,127	7,953	7,944
Southampton	12,940	15,204	16,313	16,416
Stafford	19,184	31,857	29,232	30,169
Suffolk	5,830	7,166	7,562	7,566
Surrey	9,233	11,395	12,246	16,836
Sussex	7,388	9,584	10,018	10,600
Warwick	15,111	20,257	19,926	20,181
Westmoreland	1,233	1,440	1,348	1,276
Wilts	2,586	4,379	4,143	4,132
Worcester	8,757	10,481	11,053	11,527
York—East Riding	8,792	13,672	10,734	10,791
West Riding	46,390	60,703	58,816	58,027
North Riding	8,443	8,249 - 194	8,448	8,123

Comparing the number of successful vaccinations in 1898 and in 1901 a considerable increase is seen, and the increase is maintained year by year. In 1898 the successful primary vaccinations were 500,314; in 1901, they were 710,785.

That a considerable epidemic of small-pox has been present in London and in some parts of England and Scotland for the last two years does not prove that the Act of 1898 was a failure. Vaccination had been greatly neglected for many years, and no legislation could possibly do away with the inevitable results of this neglect. All that can fairly be asked is whether the last Act is helping the cause of vaccination or the reverse, and if by any further change it could be made to help it more? On the whole we think the evidence is that the Act of 1898 is doing good, but that it might do much more if certain amendments were incorporated into it.

During the year 1898, between the date of the passing of the Act and the 31st December, 230,147 children were exempted, by their parents appearing as "conscientious objectors." In 1899 this number was increased by 32,357. In 1898 there was a large number of children who belonged properly to earlier years; their parents had ignored or resisted the law, and when exemption was permitted they claimed it. If the exemptions in 1899 prove to be about the average, it will mean that something like 3·48 per cent of all children born get exemption through the direct action of their parents. But in the year 1899 it was not 3·48 per cent, but 27·9 per cent of the children born in the year that were not vaccinated, so that after deducting the conscientious objectors, there remained in addition nearly one-fourth of all children born who, from one reason or another, were not vaccinated, and whose parents did not claim exemption. Some of these children were perhaps vaccinated later, and many probably died before the legal age for vaccination. Still the percentage who escaped by the conscience clause was small compared with the number who escaped through defects in the administration of the Act. On the other hand, the percentage of successful primary vaccinations at all ages in London, which in 1898 was only 47·7 per cent of the number of births, became in 1901 as high as 85·3 per cent, a result due mainly to the educating effect of the presence of small-pox. It is far more important to devise means of improving the administrative machine, so that 20 or 25 per cent of all children born may not evade the law, than it is to concentrate attention on the comparatively small number of conscientious objectors. In large towns a good many children probably escape registration, and they would be likely to be unnoticed by the vaccination officers, and would not even be included in the list of defaulters.

Alternatives to Vaccination.—The opponents of vaccination have tried to formulate an alternative policy, and they have done so in the two words "sanitation" and "isolation." But as to the value of these watchwords they are not unanimous. Dr. Creighton frankly admits that there is no evidence in support of the view that small-pox can be evaded or modified by sanitation. Others in his party throw "isolation" over, and speak of small-pox hospitals as "the culminating mistake in the social treatment of the disease." So that at this moment the majority of anti-vaccinators are opposed to one of their leaders about sanitation, and to another about isolation.

The truth about sanitation is that there is not a scrap of real evidence that small-pox is even considerably influenced by defective sanitary conditions, except that, if a house is very full of people, more will be exposed to the contagion than would be the case in a sparsely-populated house. The disease itself is not affected, but more people are brought into contact with its infection. There is not a shred of evidence that it is in any sense a "filth disease" as to its origin. It is no more accurate to call it a "filth disease" than it would be to say so of whooping-cough. Whether insanitary conditions of any kind can increase the malignity of the type of small-pox once it has been imported, it is impossible to say. But even if this could be proved to be true of small-pox, as it is probably true of scarlet fever and influenza, it would still be incorrect to say that the disease was due to the conditions which increased its virulence. If small-pox were bred of filth, it would be chronically present in half the villages and farm-houses in England, which it certainly is not. The other safeguard proposed in the place of vaccination is "isolation," or the separation of the sick from the healthy. Isolation aided by vaccination is no doubt of great value, but it could not be employed in an unvaccinated community. Small-pox patients cannot wait upon themselves; and if the people round them in the hospital were not protected by vaccination and revaccination, the disease would spread in the hospital exactly as it spreads outside. The whole value of taking patients out of their homes lies in the power of surrounding them with attendants who are protected by vaccination, and thus stopping the infection from spreading. There is very little treatment possible in bad cases of small-pox, and for the patient's own sake the long journey to the hospital ship or shelter would be much better avoided. The one advantage is that at the ship it is possible to prevent contact with unvaccinated people. Another point to be considered in connection with any large scheme of isolation is its cost. London is rich, and it can afford to do everything well, but the cost of transporting 70 or 80 patients a day to the ships, and of keeping 1400 or 1500 there, with the necessary service for the living, the dying, and the dead, must be enormous. The recent epidemic in London (March 1902) was estimated as having cost £10,000 per week. Revaccination would have prevented all this waste, and also an untold amount of suffering.

Amendments wanted in the Vaccination Act of 1898.—As Dr. Bond has well said, "What has been chiefly wanted to make the vaccination mills grind is motive power. That power can only come from two sources—the central or the local authorities."[1] The problem is how to get the greatest amount of motive power from each of the two, with the smallest amount of waste through friction. Perhaps it would conduce to success to leave to the central authority the duty of dealing with all the determined opponents of vaccination, of deciding when to prosecute or not, and to limit the work of the local authority to the duty of making the provisions of the Vaccination Act known to the large part of the population who are prepared to obey the law when it is authoritatively presented to them. What is aimed at is not the punishment, or even the better education of the determined enemies of vaccination, but the prevention of epidemic small-pox. The question to be asked is, Can the vaccination law and its administration be so far improved that epidemics of small-pox shall not occur in the United Kingdom in spite of frequent reintroduction of the contagion from other countries? It is absolutely certain that such reintroduction of contagion will frequently occur. In Liverpool, for instance, from 6th December 1901 to 19th February 1902, thirty cases of small-pox were imported by sea or land. In the first ten months of 1901, eight separate cases of small-pox reached Liverpool by sea, and one by land. Glasgow is in a similar position. Importation of the disease is sure to be very frequent in London. How can the population at the ports and in large centres such as London be made as immune to infection as the German population is in the frontier districts, adjacent to badly vaccinated countries, *e.g.* Russia, and up to the present time, France?

Unless the presence of contagion can be avoided, the only way to prevent an epidemic is to have the population that is exposed to the contagion immune at the time of exposure. It is not enough to try to make all exposed persons immune some days after the risk of infection has been run. If revaccination were the rule here, as it is in the German Empire, we could face the continual risk of the reintroduction of small-pox from other countries without any fear of epidemics. Can the vaccination law or its administration be still further improved towards this end?

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[1] *National Review*, March 1902,—"Small-pox." Dr. Francis T. Bond, M.D. (Lond.)

The Act of 1898 could, we think, be materially improved in four ways.

1. The administration of the Vaccination Act should be put into the hands of the local authority responsible for Public Health. At present it is worked by the Poor Law Guardians, who are not rarely elected expressly to defy the Act. They have been able till lately to appoint vaccination officers pledged to their employers not to carry out the Act. Liskeard, for instance, appointed as vaccination officer a man who had refused to have his own children vaccinated. The Local Government Board, however, did not sanction the appointment. At Leicester the Guardians declined to appoint a vaccination officer at all, but it also had in the end to submit to the Board. It is a misfortune that the administration of the vaccination law is in the hands of the Guardians. It belongs properly not to poor relief but to public health. At present the vaccination officer is selected by the Guardians; but his duty is to carry out the law to the satisfaction, not of his immediate employers, but of the Local Government Board. Even when the Guardians wish him to do as little as possible, it is his duty to put pressure upon defaulting or negligent parents to obey the law, and to have their children vaccinated. He may do that which his employers prefer, or he may prosecute defaulters and obtain legal assistance and send in the costs to the Guardians. It is not likely that, under such an arrangement, many vaccination-officers will be as active as they might be. If the administration of the Vaccination Act were put under the authority responsible for Public Health the difficulty in the way of administering the Act would be much diminished. The control of small-pox (apart from vaccination) belongs now to the sanitary authority. It has to meet all the difficulties which an epidemic of small-pox entails; no other body has the same direct interest in preventing an epidemic, and yet the one thing which can prevent it, viz., vaccination, is worked by another body, the members of which are sometimes pledged to do all they can to stultify the law. Even in a community such as Liverpool, where the Guardians do their utmost in support of vaccination, and where, in a population of nearly 700,000 people, only 26 certificates were given in 1900 to conscientious objectors, the present system works badly. The medical officer of health, Dr. Hope, shows in his report for 1901, that delay often occurs precisely at the moment when time is of the utmost value, by the health officer being unable himself to make arrangements for the immediate revaccination of "contacts" in the presence of a case of small-pox. He has to communicate with the officers of another body, and much precious time is lost.

2. Revaccination at school age should be made obligatory, subject to the conscientious objector clause as in primary vaccination. It is to systematic revaccination at about twelve years of age that Germany owes her freedom from epidemic small-pox, and there can be no security against the frequent recurrence of such epidemics in Great Britain and Ireland till revaccination is made the rule by legal enactment.

3. An adequate supply of trustworthy lymph should be provided from Government laboratories, and private practitioners should be able to buy it. The provision of enough lymph would be greatly aided by systematic revaccination at school age. A definite amount of lymph would be wanted month by month, very little panic revaccination would take place, and

there would be no waste by providing much more lymph for possible emergencies than could, in non-epidemic years, be used while it was still active. In the German Empire twenty-four State Institutions for the manufacture of trustworthy glycerinated calf-lymph are kept at work to supply the lymph for about fifty-three millions of people. The United Kingdom, with about forty millions of inhabitants, has but one Government Laboratory, from which no private medical practitioner can obtain lymph.

4. "Efficient vaccination" should be legally defined, and every certificate of vaccination should show if the vaccination had been efficient or the reverse, and its date.

The cost of isolating small-pox patients should be borne as far as possible by the head of the family in which each case occurs. "Objectors" might be required to show that they had made, through benefit or insurance societies, arrangements to meet this liability before exemption certificates were given them. As at present arranged the enormous cost of a small-pox epidemic is not felt by the people who cause it, but by the overburdened rate- and tax-payers generally.

In addition to the improvements now suggested in the vaccination law, indirect social pressure should be applied in every direction in support of obedience to the law. All who realise the amount of suffering, waste of valuable lives, and loss of money and energy in fighting small-pox epidemics ought to do all in their power to assist the vaccination laws by informal and mild compulsion applied in their support. The certificate of efficient revaccination should be asked for as a preliminary for every kind of employment. Domestic and outdoor servants, shop assistants, clerks in offices and banks, school teachers, parish workers, servants in hospitals, tenants of flats and chambers, the employés of dressmakers, tailors, bootmakers, builders, and carpenters, men and women in factories, stokers, sailors, and officers in steamers, would-be life-insurers, proposers for election into social clubs, should all be required to show their precious Certificate of Revaccination. No one ever hears of a man refusing a good post in the Police, or Post Office, because he will not be revaccinated; and if the certificate were continually in demand as a step to employment, it would be obtained and valued. It is for the medical profession to aim at making vaccination efficient, and a perfectly safe and painless operation. Till these results are achieved there will continue to be opposition and prejudice in the minds of the ignorant. The Act of 1898 did great good by enforcing more care in the performance of vaccination. Every medical practitioner should realise the evil effect of "vaccination accidents," even when not fatal, in the formation of public opinion against vaccination. It is only by the creation of a sound opinion as to the immense value of vaccination that legal enactments in its support can be so administered as to overcome the natural inertia of the less instructed classes of the community.

The summary of all available evidence as to the value of vaccination cannot be better stated than in the words of the Royal Commissioners in their final report, dated August 1896. They say: "The conclusions as to the value of vaccination arrived at by the Commission are as follows:—We think—

1. That it diminishes the liability to be attacked by the disease.
2. That it modifies the character of the disease, and renders it (*a*) less fatal, or (*b*) of a milder and less severe type.
3. That the protection it affords against attacks of the disease is greatest

during the years immediately succeeding the operation of vaccination. It is impossible to fix with precision the length of this period of highest protection. Though not in all cases the same, if the period is to be fixed it might, we think, fairly be said to cover in general a period of nine or ten years.

4. That after the lapse of the highest protective potency, the efficacy of vaccination to protect against attack rapidly diminishes, but that it is still considerable in the next quinquennium, and possibly never altogether ceases.

5. That its power to modify the character of the disease is also greatest in the period in which its power to protect from attack is greatest, but that its power thus to modify the disease does not diminish as rapidly as its protective influence against attacks, and its efficacy during the later periods of life to modify the disease is still very considerable.

6. That revaccination restores the protection which lapse of time has diminished, but the evidence shows that this protection again diminishes, and that to insure the highest protection which vaccination can give the operation should be at intervals repeated.

7. That the beneficial effects of vaccination are most experienced by those in whose case it has been most thorough. We think it may fairly be concluded that where the vaccine matter is inserted in three or four places it is more effectual than when introducd into one or two places only, and that if the vaccination marks are of an area of half a square inch, they indicate a better protection than if their area be at all considerably below this."

Vagina, Disorders of the

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DEVELOPMENT (see vol. iv. p. 154)
MALFORMATIONS (see p. 153 *et seq.*)
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VAGINAL SECRETION.—Among the functions of the vagina that of excreting the products of the internal genital organs is one of the most important. In the interior of the canal are thus found constantly, in greater or less quantity, menstrual blood or various other discharges from the body and cervix of the uterus. The vagina itself is lined by a stratified squamous epithelium, and its mucous membrane is normally unprovided with glands. Doubts have, therefore, arisen as to whether the vagina itself secretes, or whether the materials found in its lumen do not all come from above. It is observed, however, that after complete removal of the uterus the normal vagina continues to have a moist surface; and that in those severe cases of prolapse, where only the lower half inch or so of the posterior wall remains *in sitû*, the exposed part of the vagina becomes dry and horny, while the part of the lumen which is preserved remains moist as usual. Hence it appears that the vagina does actually secrete, though under normal circumstances the amount of the secretion is small.

The normal secretion is a more or less viscid, tenacious fluid like thick starch mucilage. It has an acid reaction and chemically contains albumen but no mucin. The opaque whiteness of the secretion is due to desquamation of the superficial layers of the epithelium, and to the presence of a small number of leucocytes. The fluid part of the secretion probably consists of serum, which has transuded from the vessels of the papillæ in the sub-epithelial layer of the vaginal wall. The acid reaction is probably caused by the presence of fatty acids; these are due to the growth of the bacillus vaginæ, which appears to set up decomposition in the secretion immediately after it reaches the vaginal lumen.

Another important function of the vagina is to protect the internal generative organs against the entry of germs; a function the performance of which is rendered difficult because the means that prevent the entry of living germs must not interfere with the life of spermatozoa. In secretion taken from the vagina cocci and bacilli of many different varieties are found, and among them chain and cluster cocci, which are believed by one set of observers to be pyogenic organisms in a state of diminished virulence, and by another to be simple saprophytes. All these are derived from the vulva, and it is certain that along with other varieties septic and pathogenic germs must from time to time enter. It has been shown, however, by experiment that the vagina can actually free itself of a living culture of certain organisms in the course of from a few hours to two or three days. The healthy vagina thus appears to have some means of ridding itself of living disease germs that may gain an entrance, but as regards the nature of this bactericidal influence little is known. The acid reaction, the antagonism of different varieties of germs, phagocytosis, mechanical removal, and the absence of oxygen, have all been considered, but none of them offers a satisfactory explanation of what appears to be a certain fact, namely, that the vaginal secretion is a strong antiseptic and disinfectant. In pregnancy the bactericidal power of the secretion appears to be even more marked than in the non-pregnant condition.

While thus the healthy and intact mucous membrane is able to deal successfully with the injurious germs which find an entrance, under certain circumstances, as after injuries, labour or abortion, septic or pathogenic organisms are able to establish themselves in the vagina. As a result diseased conditions may be set up, either in the pelvic organs and tissues or in the more remote parts of the body. Locally, the germs luxuriate in the natural lumen of the genital canal, causing local inflammations and general septic intoxication; or they may invade the tissues themselves and spread along the tissue spaces, the lymphatics, or the blood vessels, in which case local inflammations also result, along with true septicæmia or pyæmia. The micro-organisms that are of most frequent importance in these connections are, in addition to many varieties of putrefactive germs, the pyogenic organisms, including the bacterium coli commune, and the gonococcus.

This fact that disease germs are able to enter through the vagina and to set up serious disease affecting the whole body or remote parts of it, as in septicæmia, pyæmia, and allied conditions, may prove to be of even greater importance than has hitherto appeared. One of the main advances recently made in general pathology has consisted in the discovery of the large part that infection by micro-organisms plays in the production of disease. Thus peritonitis is now understood always to be produced by the action of germs, and the so-called idiopathic form of the disease has almost disappeared even from the text-books. Endocarditis is due to infection with germs of divers kinds, among which the gonococcus is of the greatest interest in the present connection. In the joints again, as Howard Marsh (*Brit. Med. Journ.* vol. ii. 1902, p. 1831) remarks, inflammation, while never idiopathic, is frequently infective. Acute rheumatism is also most probably due to invasion of the body by germs, and it is possible that the great class of chronic rheumatic and rheumatoid affections may also prove to be due to bacterial infection, as is suggested by Dr. Chalmers Watson (vol. x. p. 444). Various affections of the internal organs have thus been proved, or are likely to be proved, to be caused by germs, and many of them, such as arthritis and pericarditis, may be due to the action of any one of a large number of different germs. Arthritis, for instance, may be set up not only by the ordinary septic and pyogenic organisms, by the gonococcus or the tubercle bacillus, but is also not rarely due to the pneumococcus and to the germs of typhoid fever, influenza, scarlet fever, dysentery, or erysipelas. Where the dependence of a disease on a particular germ has been proved, it is not always obvious by what road the germ gained an entrance to the body; such entrance must take place through one of the natural mucous-lined orifices of the body or through a breach of the surface. That the vagina is frequently the portal by which admission is gained is abundantly clear in certain diseases, such as septicæmia, pyæmia, gonorrhœa becoming generalised, and in some cases of tubercular infection. It may well be proved in the future that the vagina serves also as a frequent port of entry for germs that give rise to certain other affections, such as rheumatism and pernicious anæmia, whose etiology is at present obscure. Thus leucorrhœa in many of its forms may acquire a greater significance, and may call for more serious consideration than is frequently given to it now.

INFLAMMATORY AFFECTIONS

VAGINITIS.—Inflammation may affect any part of the vaginal wall from the hymen to the cervical attachment, and may be more or less limited to the mucous membrane, the muscular wall, or the connective tissue sheath. Nothing is known with respect to inflammation of the muscular coat apart from that of the other layers of the wall. Inflammation of the connective tissue surrounding the vagina is known as peri-, or better paravaginitis, and will be referred to later on. Inflammation of the mucous membrane lining the vagina is by far the most frequent form, and to it the use of the terms vaginitis or colpitis is confined. The covering of the vaginal cervix has a similar structure to the mucous membrane of the vagina, and is affected by inflammation in similar ways; hence inflammatory affections of this part of the cervix are frequently referred to as vaginitis of the portio, and should be considered along with those of the vagina.

The lining of the vagina has rather the characters of skin than of mucous membrane; it is covered by a thick stratified squamous epithelium, and has no glands, and is thus little prone to become inflamed. On the other hand the lining is very vascular, is exposed to many injurious influences, and the changes that take place in menstruation, pregnancy, and childbed predispose it to inflammation. This predisposition may be increased by hyperæmia, passive as in affections of the heart, lungs, and liver, or active as in sexual excesses, and by changes in nutrition in such affections as chlorosis, anæmia, and Bright's disease. The exciting causes of inflammation come from outside the body and may be mechanical, as in the case of lacerations or foreign bodies, thermal as in burns, chemical as in the use of caustics, or infective from the action of germs. Or they may come from inside as in the case of fistulæ, where decomposing urine or fæces may irritate the mucous membrane, or in septic, carcinomatous, or other ulcers, from which the putrid or purulent discharges flow over the surface. Not unfrequently a vaginitis arises by extension from the neighbouring surfaces of the vulva, cervix, or body of the uterus. It is probable that in nearly, if not quite, all cases the *causa causans* is a micro-organism, but much work yet remains to be done before this can be looked upon as scientifically proved.

Vaginitis may be divided into catarrhal, exudative or pseudo-membranous, ulcerative, and specific.

1. CATARRHAL VAGINITIS is by far the most common form; it may be acute or chronic, and is characterised by alterations in the secretion, and by redness and sometimes swelling of the mucous membrane. The secretion shows changes in quantity and in quality; in some cases there is an increased desquamation of the squamous epithelium cells in the form of thick, white flakes like milk curds, and in other cases the discharge of serum is increased, and gives rise, with these whitish masses, to a more or less milky, serous fluid. In acute infective processes suppuration occurs, and causes the discharge to take on a yellowish tinge; the more acute the process, the more yellow and purulent is the secretion.

The vaginal mucous membrane varies in appearance with the age of the patient and the acuteness of the process. In acute cases in young women the whole surface is diffusely reddened; but careful examination shows even here that the redness is more marked on the summits of the folds of the mucous membrane. The redness varies in shade in different cases, and there is sometimes a slight bluish tinge added to it. It may be equally diffused over the whole vagina or may be limited to a part, especially near the entrance or at the upper part of the posterior wall. In milder and more chronic cases red spots and streaks are the only signs, and these spots are specially marked in the vagina of old women where the general surface of the mucous membrane is smooth and yellow. The redness may be due to congestion, and disappear on pressure, or to ecchymosis, in which event the colour does not disappear on pressure (macular vaginitis). In some cases where the inflammation is more intense, and especially in pregnancy, the spots form distinct prominences (granular vaginitis). Rarely, a little fluid accumulates in the spots (vesicular vaginitis); as a rule the vesicles have no special importance, but they have occasionally been found in conjunction with skin pemphigus. Occasionally, in more chronic conditions, there is hypertrophy of the papillary bodies, and the epithelium becomes secondarily hypertrophied, so as to form small white, firm, warty elevations, which are found scattered over the vagina or portio, feeling like grains of sand (warty vaginitis). This condition is usually, but not always, a gonorrhœal affection, and is especially met with during pregnancy. Sometimes, especially in elderly women, but occasionally also in younger ones, erosion of the epithelium covering the red spots takes place so as to lay bare the inflamed papillæ, which may then become adherent to similar spots on the opposite wall by fine bands or membranes, easily breaking down, with slight hæmorrhage, under the pressure of the examining finger (senile adhesive vaginitis). In addition to the increased redness of the mucous membrane, there is sometimes, especially in young women with acute catarrh, distinct œdematous swelling; in such cases the lining of the vagina is of soft, velvety consistence.

Microscopically, vaginitis is characterised in the more acute forms by injection of the blood-vessels, and by diffuse infiltration of the papillæ with small round cells, which are also found wandering through the epithelial layer in considerable numbers. The red spots above described are found to be due to increased vascularity and infiltration with round cells of a group of papillæ. The individual papillæ in such a group swell laterally and tend to become confluent, and also extend vertically, so as in some cases to become prominent above the surface. The epithelium covering such a spot may become thin, allowing the red colour of the papillæ to shine through, or may be thrown off, so as to lay bare the papillæ; or, in more chronic cases, may become greatly hypertrophied and thickened so as to form warty elevations.

Gonorrhœal Vaginitis.—Among the causes of vaginitis the gonococcus is the most frequent and the most important. This germ sets up an acute purulent vaginitis, which shows the usual naked eye and microscopic characters of a severe catarrh, with the addition that gonococci in smaller and larger heaps and chains are found scattered through all the layers of the epithelium, either between the cells or typically inside the epithelium cells or pus corpuscles. Sometimes the germs are found to have penetrated deep into the sub-epithelial connective tissue. The course of gonorrhœal vaginitis is usually towards rapid recovery, the disease frequently, however, persisting in the cervix and urethra. In some cases the acute vaginitis gradually subsides into a chronic catarrhal inflammation, often with acute exacerbations, which are due to repeated infections, either from without or from the cavity of the cervix or body of the uterus.

The diagnosis of the gonorrhœal nature of a vaginitis depends on the recognition of the gonococcus; the vaginal secretion of adults is not suitable for this observation, and therefore the search has to be made in secretions taken from the urethra or cervix. The absence of gonococci does not prove that the inflammation is not gonorrhœal, but the examination should be repeated after a menstrual period, or during an exacerbation of the catarrh. In chronic cases clinical signs are of great importance. Thus an acute, purulent urethritis is only rarely due to any other cause than gonorrhœa; chronic urethritis with milky secretion is most frequently the remains of an old acute gonorrhœal affection, though it is certainly sometimes observed without gonorrhœa. Infection of Skene's ducts, and red spots round the urethra have a similar import. Purulent infection of

Bartholin's glands, pus escaping from their ducts, tumours, abscesses, or cysts in the characteristic position of the glands, are all very suggestive, but not diagnostic of gonorrhœa. Red spots like flea-bites about the orifices of Bartholin's ducts—the macula gonorrhoica of Sänger—are also suggestive; and vulvar warts are usually but not always due to gonorrhœa. The probability of a gonorrhœal origin is greater when there is disease of the appendages, especially purulent salpingitis and pyosalpinx, with recurrent acute attacks of pelvic peritonitis. The history of the onset has only a limited value; the immediate commencement of a purulent inflammation after sexual connection or after marriage, and the occurrence of pain and frequency in micturition at the onset, have some value; the recognition of gonorrhœa in the male is important, but not often available.

Mycotic vaginitis is found most frequently in pregnant women with gaping vulva, and is characterised by bright redness and swelling of the mucous membrane, which is covered with small white patches rarely exceeding a pin-head in size. Discharge is absent in most cases, but where present it is of an irritating, excoriating character. The patients complain of intense burning, smarting, and itching, and the mucous membrane is excessively tender to the touch. The affection is caused by the growth of the oidium albicans or some allied organism, which is derived in many cases from an infant suffering from thrush. The disease is more frequent in summer, and damp dwellings appear to favour its occurrence.

Emphysematous Vaginitis.—This occurs most frequently during pregnancy, and then tends to disappear within a week or two after delivery; less frequently it is found arising in the puerperium. Small soft elevations, rarely larger than a pea, are found scattered singly or in groups over the surface of the vaginal mucous membrane; on the summit of the elevations the epithelium is often so thin that the projection is seen to be hollow, with the contents shining through; on pricking such an elevation it collapses, but no fluid, or only a very minute quantity, exudes; a little gas can sometimes be heard to escape with a hissing sound, or if the puncture is made under water a gas bubble is seen. The rest of the mucous membrane as a rule shows nothing peculiar; the vaginal secretion is usually somewhat increased, and is not seldom frothy. Zweifel found trimethylamine in the gas.

Under the microscope the changes are very characteristic; the connective tissue close under the epithelium is pervaded by round, elongated, or irregular cavities lying more or less close together. These cavities are not lined by epithelium or endothelium, but represent simple clefts in the connective tissue. In the immediate neighbourhood of nearly all the cysts there is a fairly considerable number of large giant-cells with many nuclei, exactly like the giant-cells found in tuberculous collections. In addition, the connective tissue in the neighbourhood of the cavities shows dilated capillaries and profuse infiltration with small round cells. The cause of the condition is a micro-organism, but observers are not yet agreed as to its characters; it appears to be a bacillus. The affection tends to spontaneous disappearance after delivery, and calls for no special treatment.

Exfoliative Vaginitis.—Exfoliative vaginitis is a rare affection which is characterised by the discharge of membranous casts of the vagina, frequently accompanied by dysmenorrhœal symptoms. The vaginal membranes are composed of masses of squamous epithelium cells, and are readily distinguished from the uterine by the absence of the openings of the glands. The use of strong astringent injections is sometimes followed by the discharge of larger or smaller shreds of membranes, which may even form casts of the whole length of the vagina.

Vulvo-vaginitis of Children.—Vaginitis is a frequent and obstinate complication of the vulvitis that is observed in infants and young children. This vulvitis may be due to various causes. Dirt is one of these, and worms forms a second; these are, however, rarely efficient in setting up an inflammation of the vulva. The exciting cause in the great majority of cases is a micro-organism. Of the germs giving rise to vulvitis, by far the most frequent and important is the gonococcus, which is conveyed by means of unclean linen, bedclothes, or towels; thus Robinson (*Obst. Trans.* 1899, vol. xli. p. 14) investigated fifty-four cases of vulvitis in children, and found that in forty-one, or nearly 76 per cent of them, the gonococcus was present in the discharge. In further proof of the infective nature of many of these cases are the facts that frequently the affection occurs in epidemic form, and that in many instances some other person in the same household is affected by a gonorrhœal, or at least a suspicious, discharge.

Many cases of vulvitis yield readily to simple treatment. A large proportion, however, obstinately resist medication, and it is found on closer examination that these are usually complicated by the presence of a vaginitis. The vaginitis is shown, in some cases, by the escape of pus at the vaginal orifice. Examination of the vagina, which may conveniently be done even in the youngest child by means of Kelly's bladder speculum, shows that some portion of the vaginal mucous membrane is red and raised above the surface and secreting. These patches are most commonly found in the upper part of the vagina, especially on the posterior wall. Treatment must be directed to the vaginal condition as well as that of the vulva; the most convenient methods of treating the vaginitis are by passing thin bougies composed of cocoa-butter or glyco-gelatin, and containing iodoform, boracic acid, or protargol, and by injecting by means of a syringe with a long fine nozzle some solution, such as one of nitrate of silver, 5 to 10 grains to the ounce. At the same time, the usual treatment appropriate to uncomplicated vulvitis is required, along with careful attention to the general health of the child.

2. PSEUDO-MEMBRANOUS VAGINITIS.—Pseudo-membranous vaginitis is rare, and in the vagina, as elsewhere, no sharp division is possible between superficial and deep processes. The pseudo-membranes appear as small grey patches, which form especially on the summits of the folds of the mucous membrane, and by increasing in size and joining other patches may form extensive membranes. The mucous membrane surrounding the grey patches is as a rule markedly red and swollen, and may show scattered hæmorrhages. When the membranes are removed small erosions or superficial ulcers are left, the healing of which, especially when they are situated in the upper part of the vagina, may lead to narrowing or atresia. This pseudo-membranous vaginitis is rarely met with as a real diphtheria due to Löffler's bacillus; sometimes it is present as a complication of the acute exanthemata, of cholera, typhoid fever, or dysentery. In these cases the process may extend more deeply and give rise to true ulcers, or sometimes even to dissecting para-vaginitis. The putrid discharges from a gangrenous ulcer, especially when complicated with urinary fistulæ, may also lead to pseudo-membranous inflammation of the lower part of the vagina. After labour a similar condition may arise, especially in the so-called diphtheritic endo-

metritis, or the surface of injuries caused by labour may become covered with a grey layer—puerperal wound diphtheria.

3. Ulcerative Vaginitis.—Small superficial erosions are not infrequent in catarrhal vaginitis or as a result of slight injuries or of the application of caustics. In these cases there is no destruction of the connective tissue under the epithelium, and no scar is formed, although adhesions to other similar erosions may take place. Sometimes, however, as a result of inflammation there is actual destruction of more or less of the connective tissue with consequent formation of scar tissue. For instance, what for want of a better name may be termed *pressure sores* are met with either in the normally situated or in the prolapsed vagina. In the former case the most frequent cause is an ill-fitting pessary, which by its pressure gives rise to local anæmia and superficial gangrene; in this variety of pressure sore, long-continued irritation gives rise to extensive, small round-celled infiltration around the ulcer, and the pessary may eventually become buried in granulation tissue, which, after the removal of the offending object, may contract so as to cause stenosis or atresia of the vagina. In some cases the pressure may be so severe or long continued as to cause perforation into the bladder or rectum.

In old-standing cases of prolapse deep ulcers sometimes form which may attain the size of the palm of the hand, or may be multiple; they are usually met with on the anterior wall of the vagina and near the attachment to the cervix; the form of the ulcer may be round, triangular, or more often irregular; the edges are sharply defined and slope towards the base of the ulcer, which is depressed and covered by a dirty greyish layer, sometimes with scattered imperfect granulations; the neighbourhood of the ulcer is not reddened or infiltrated. The cause in these cases is partial strangulation along with repeated irritation, mechanical by friction against the thighs and clothes, and chemical by the flow of decomposing urine over the surface.

Parturition is another fertile source of ulcerative vaginitis; in every labour there arise in the vagina breaches of surface which may be converted into ulcers by the action of septic or pathogenic germs. Such ulcers show a firmly adherent greenish grey membranous deposit, which is composed chiefly of dead tissue, and often leads to the term diphtheritic being erroneously applied to the affection. In the base of the ulcer and in its neighbourhood there are œdematous swelling and profuse infiltration of the vaginal walls, and the whole vagina is often swollen and brawny as the skin is in erysipelatous conditions; hence this condition has been described as erysipelatous vaginitis. In the more severe forms the inflammation spreads in the para-vaginal tissues and upwards to the rest of the pelvic connective tissue, the whole of which may become involved as the result of a severe infection in a quite small injury. The most frequent cause of this severe type of puerperal vaginitis is the streptococcus pyogenes.

A similar affection may occur as the result of operation wounds where antiseptic measures have been imperfectly carried out, or of other injuries inflicted upon the vagina. Ulceration may also arise secondarily from suppuration in the neighbourhood, and perforating the walls of the vagina; the forms of suppuration most frequently found pointing in this direction are para-metritic abscesses and suppurating hæmatoceles.

4. Specific Inflammations and Ulcerations.—Certain specific causes in addition to those already mentioned are also found giving rise to ulceration or to inflammation of the vagina, and it will be convenient to mention

some of them here. Sarcoma and carcinoma usually, and simple tumours occasionally, are found inflamed and ulcerated. Tuberculous disease is usually met with in the form of ulceration. A *simple round ulcer* has been described by Zahn; this ulcer was circular in shape, had a red base and sharply defined sloping edges, and was supposed to be due to arterial sclerosis leading to deficient nutrition of a circumscribed portion of the vaginal wall. It is at least possible that this ulcer may have been tuberculous in origin.

Syphilis in any stage may be found affecting the vagina; the primary chancre is rare; in the secondary stage red patches or papules or mucous tubercles are observed; in the tertiary period deep gummatous changes are occasionally met with. Soft sores have been observed in the vagina, and as a rare occurrence phagedænic sores resembling those found on the penis have been encountered.

This is probably the most convenient place to mention NOMA of the vagina, although it is really a gangrenous process. Noma usually spreads inwards from the vulva, but has occasionally been found arising primarily in the vagina, even at its upper part, where it very soon spreads to the cervix and often to the bladder. In many cases Noma of the face has been present at the same time.

TUBERCULOSIS OF THE VAGINA.—Tuberculosis of the vagina as a primary affection is extremely rare, only one well-authenticated case having been placed on record. Secondary tubercle is very uncommon; it is generally secondary to disease of the uterus or vulva, and is thus usually situated at the upper end of the vagina or just above the entrance. It is also sometimes met with in pulmonary tuberculosis, or in conjunction with disease of the urinary organs or of the rectum. The miliary form of vaginal tuberculosis, where greyish-white tubercles are found disseminated, or grouped, or sometimes joining to form small nodules, is extremely rare. Usually the disease when present gives rise to an ulcer with edges sharply cut, more or less irregular or jagged, not raised or thickened; the base of the ulcer is uneven and discoloured with caseous spots and patches; there is a red areola in which, as well as in the base of the ulcer, small miliary tubercles may be recognised; and the ulcer is sometimes very tender. Occasionally in advanced cases of the affection recto-vaginal or vesico-vaginal fistulæ are found. Microscopic examination of the edges and neighbourhood of the ulcer shows the usual collections of round cells, together with giant-cells, and the characteristic bacilli.

THE TREATMENT OF VAGINITIS calls for the employment of general as well as local measures. Any constitutional tendency or taint, such as struma, gout, rheumatism, or syphilis, should receive attention; the general health must be improved by every possible means, and care is to be taken to encourage the regular and adequate action of all the excretory organs, —the bowels, kidneys, skin, and lungs. The local treatment varies with the stage and activity of the disease. In acute cases rest in bed is required. The exciting cause must, where possible, be removed, and care taken to prevent other causes arising or persisting; thus foreign bodies must be taken out, harmful or dangerous germs removed or destroyed by antiseptic applications, and discharges or membranes, which offer a suitable medium for the growth of germs, must be got rid of. Finally, means must be employed to further the formation of healthy epithelium, and where there is any deeper loss of tissue to promote granulation.

The methods that have been devised to meet these various indications may be divided shortly into treatment by wet methods, treatment by tampons, and the dry methods of treatment. Among the wet methods *douches* are chiefly useful in aiding to get rid of discharges and other products of inflammation; they should be employed in quantities of at least 3 or 4 pints, warm at a temperature which is most grateful to the patient, and should be administered at low pressure, the douche-can being raised not more than 18 inches above the level of the pelvis; the douche ought further to be given slowly, and the patient should lie down during its continuance and for at least 10 minutes afterwards. Danger arises from the employment of too great pressure, especially at the time of menstruation. Water alone should never be employed, as it appears to promote the growth of putrefactive germs in the vagina; and generally all non-astringent substances are objectionable, as they tend to macerate the surface epithelium. Sometimes, however, especially in the early stages of acute vaginitis, emollient and sedative douches are of service; for this purpose gruel or linseed-tea, or water with the addition of lead lotion, or of borax and soda, may be used. In sub-acute or chronic cases antiseptics or astringents are more useful, and for these purposes there is a wide choice, so that only a few of the more serviceable medicaments can be mentioned here. As antiseptics chlorine water, permanganate of potash, boracic acid, corrosive sublimate, creolin, and lysol are most in use; and among astringents which are at the same time antiseptic, the sulphates of copper, zinc, and iron, nitrate of silver, the acetates of lead, zinc, or aluminium, oxycyanate of mercury, tannin, and alum.

Fluids may also be applied by means of what is known as the "local bath of the vagina." A cylindrical speculum is introduced into the vagina and filled with solution of sulphate of copper (2 to 5 per cent), nitrate of silver (5 per cent), pyroligneous acid, or solution of protargol; as the speculum is moved about and withdrawn the solution comes closely into contact with every part of the surface of the mucous membrane. Stronger fluids may be pencilled on to the surface or to some part of the surface with a brush; in this way pure alcohol, tincture of iodine, or strong alum solution may be employed; in syphilitic affections a thick paint made of calomel, salt, and water, and painted over the surface, is specific.

The tampon treatment is best carried out by the medical attendant, who through a Sims' speculum places pledgets of wool first in a circle round the cervix and then so as to fill the whole vagina. In this way direct pressure is obtained on the walls, in addition to the action of any drug that may be chosen. As a vehicle for the applications glycerine is best; in it may be dissolved alum, boric acid, ichthyol, iodine, or potassium iodide, tannin, and iodoform. Instead of the wool tampon a gauze strip saturated with some of the above-mentioned solutions is sometimes introduced into the vagina. Applications of this kind require to be renewed every two to four days.

Among the dry methods of treatment may be mentioned the use of medicated pessaries made with glycerine and gelatine, or with gum arabic; the use of the "powder bottle," a strip of gauze 8 inches by 4 inches in which is wrapped up a drachm of tannin and boracic acid or tannin and iodoform, of alum sugar 1 in 20, airol, or other powder; the insufflation of powders; or the introduction, on wool tampons or by means of a syringe, of ointments made of vaseline or lanolin to which astringents may be added, such as nitrate of silver, boracic acid, ichthyol, or white precipitate ointment. The ointment method is specially indicated where the entrance of the vagina is narrow, and in young children. The methods of dry treatment are especially useful in out-patient practice. In pregnancy no strong astringents should be employed in the treatment of vaginitis, but where necessary warm weak solutions of borax and soda, of boracic acid, or of permanganate of potash may be employed with safety.

5. PARA-VAGINITIS.—Inflammation of the connective tissue surrounding the vagina is most frequently caused by wounds, especially small ones, occurring in labour, and becoming infected. Operations carried out with insufficient antiseptic precautions, neglected pessaries, and instrumental attempts at criminal abortion may also give rise to the affection. Occasionally in certain diseases, such as typhoid fever and pneumonia, a purulent inflammation undermining large parts or the whole of the vaginal wall has occurred (phlegmonous dissecting para-vaginitis). The intimate causation of this affection is still obscure, and it is possible that it may not unfrequently run its course in young people with typhoid fever, variola, scarlet fever, and possibly measles, without attention being called to the symptoms.

Diffuse or circumscribed collections of pus may make their way high up along the connective tissue surrounding the vagina and even into the bases of the broad ligaments. Portions or the whole of the vaginal wall may be cast off as sloughs. Infection may be conveyed by the lymphatic vessels to the pelvic glands and even to the peritoneum. When the patient recovers cicatrisation may lead to varying degrees of stenosis or to complete occlusion of the vagina, with its sequelæ.

The symptoms may be overshadowed by a grave general disease. They consist in fever and local pain, with purulent and bloody discharges, and the separation of sloughs.

Treatment.—The separation of gangrenous portions of the vaginal wall should be promoted by warm antiseptic applications, and after the separation of the sloughs, efforts should be made to prevent the contraction of the resulting scar tissue.

VAGINISMUS is the term applied by Marion Sims to certain spasmodic conditions of the pelvic floor which he was the first adequately to describe. In patients suffering from the affection any attempt at sexual intercourse calls forth violent contraction of the muscles surrounding the vagina, and if the efforts are persisted in the woman frequently cries out involuntarily in fright and pain, and may assume an appearance of abject terror. The spasm affects the sphincters of the vagina and anus, the small perineal muscles, and the levatores ani; and it frequently extends to other muscles, more especially those of the buttocks and the adductors of the thighs. When such a patient presents herself for advice the gentlest attempt at examination usually calls forth similar phenomena and fails in its object. Complete local investigation is therefore possible only when the patient is anæsthetised, and in a well-marked case, unless the anæsthesia is deep, a touch on the genitals immediately calls forth the spasm. Careful examination may fail to disclose any abnormal physical condition; more frequently lesions are discovered, though these are often slight in appearance. The most common appearance found consists in red spots and patches at the urethral meatus, and in the vulva just outside the hymen or its remains. Sometimes one or more of the carunculæ myrtiformes shows the same red patches, which are due to thinning of the epithelium accompanied by increased vascularity and round-celled infiltration of the superficial layers of the corium. In other cases small fissures or excoriations may be present at the entrance of the vagina. Occasionally a more remote cause may be found for the spasm, such as a vaginitis, a prolapsed ovary, or a fissure of the anus.

Opinions differ widely as to the essential cause of the spasm. According to one group of authors, some painful local condition is always the determining factor, and where no lesion can be discovered at the time of examination it is supposed that, after originating the vaginismus, the local condition has healed and left no trace. According to another set of observers the affection is a neurosis, and is set up by crude or imperfect attempts at coitus. It is probable that each of these theories expresses a part of the truth, and that in some cases the condition is a pure neurosis; but much more frequently the spasm is set up by some small injury or painful inflammatory condition. In many cases it has appeared to the present writer that the exciting cause has been a result of gonorrhœal inflammation of the urethra and vulva, probably derived from a chronic urethritis or gleet in the husband.

The *treatment* calls for much patience and tact; any local lesion that may be discovered must be treated, and cautious inquiries should be made into the husband's condition, so that any lesion in him may be treated at the same time as the vaginismus. The most successful treatment consists in forcible digital dilatation of the vulva under an anæsthetic followed by the daily passage of a vaginal dilator. For this latter purpose Hegar's dilators do very well. At first cocaine should be applied to the vulva before passing the bougie; a small size is used to begin with, and after being passed is fixed in position with a T-bandage and retained for one or two hours. Each day a larger size should be passed, until a dilator 1 inch in diameter can be used; then the bougies should be passed daily without the use of cocaine, again beginning with a smaller number and gradually increasing the size. It is of great importance not to cause pain during the passage of these bougies; otherwise the patient's confidence is destroyed. No undue haste should therefore be employed in increasing the size of the bougies. The treatment usually extends over at least three weeks, and may be considered complete when a bougie 1 inch in diameter can be passed without cocaine.

New Formations

Vaginal Cysts.—Cysts in the wall of the vagina are not in all cases derived from the elements of the vaginal wall itself, but on account of their common situation it is convenient to consider all such cysts together. They may arise from Gartner's duct, from the glands that are occasionally found in the vagina, or by adhesion of the contiguous summits of folds of the mucous membrane. Possibly also certain of them may be derived from dilatation of the lymphatic vessels, or as the end results of injuries which have given rise to hæmatoma. From some or all of these sources vaginal cysts are fairly common; they rarely give rise to symptoms, and thus are usually discovered accidentally. As a rule varying in size from a pea to a walnut, they are occasionally larger and may rarely attain to the size of a child's head, in which cases they may seriously interfere with labour and the other functions of the pelvic organs. Cysts are most frequently found in the anterior and lateral walls of the vagina, but are not rare on the posterior wall; they are usually superficial, and over the apex the mucous membrane is often thinned so that the cyst contents are seen shining through; rarely a cyst may become pedunculated. The smaller cysts extend into the para-vaginal connective tissue; the larger ones may extend upwards to the side of the uterus and spread into the parametrium. Frequently more than one cyst is present, and several are sometimes found arranged in a series parallel to the longitudinal axis of the vagina. Diagnosis is easy on combined examination by the vagina and abdominal wall, aided, if necessary, by the finger in the rectum and a sound in the bladder. The consistence is more or less firm elastic. The best treatment is by excision, but this is frequently not possible, the wall of the cyst forming merely a condensed layer of the surrounding connective tissue. Where excision is possible the resulting wound may be brought together by superimposed layers of suture, or may be packed with gauze and allowed to granulate. A simple incision into the cyst is useless. Where excision cannot be done, a portion of the wall must be excised and the remains of the cyst treated by curetting, by the actual cautery, or by some strong caustic such as Liquor ferri perchlor. Where the lining of the cyst is not destroyed a small depression secreting mucus may persist after operation.

Myoma and Fibroma.—Myoma and fibroma are rarely found in the vagina; they originate from the fibro-muscular wall. They form round tumours, seldom larger than an apple, and are embedded in or attached by a pedicle to the surface of the vaginal wall. The surface of the tumour may be smooth or lobulated, and is covered by intact mucous membrane. The consistence is usually hard like that of a uterine fibroid, but may be soft and fluctuating where œdema or cysts are present. The tumour is, as a rule, sharply marked off from the surrounding tissues, but sometimes spreads diffusely into them. The anterior wall of the vagina is much more commonly affected than the other walls; occasionally more than one tumour may be present. The treatment consists in making an incision over the tumour and enucleating it; the bed of the tumour is then either brought together by series of buried sutures, or partially closed and drained; where the tumour has become pedunculated it is removed after division of its pedicle.

Sarcoma of the Vagina.—Sarcoma of the vagina presents marked differences according as it is met with in childhood or in adult life. In infancy it occurs as a polypoid tumour affecting, in the great majority of cases, the anterior wall. In its early stage it occurs as a more or less pedunculated growth, which, as a rule, first attracts attention by protruding into the vulva. As the tumour grows it forms a mass having numerous projections from the surface, which lend to it an appearance somewhat resembling that of a bunch of grapes or berries. As the disease progresses, the cervix and bladder tend early to become involved, and later the vulva and the inguinal glands; the uterine body and the broad ligaments frequently are implicated; the rectum never is invaded. In the later stages of the disease ulceration may take place, and lead to infection and the death of the patient; pyometra and purulent peritonitis have been several times observed. In other cases the tumour may cause death by pressing on the urethra, and setting up dilatation followed by infection of the bladder, ureters, and kidneys. Remote metastases do not appear to be common; in one case, however, the left ovary was found enlarged to the size of an orange.

Microscopically the tumour is a sarcoma composed of round and spindle-cells with some giant-cells; a varying quantity of connective tissue and some smooth muscular fibres are generally present; striated muscular fibres have been observed in many cases.

The first symptom frequently is the appearance of the tumour at the vulva; sometimes, however, this is preceded by pain in the pelvic region, which may be attended by bleeding, troubles of micturition, and, not unfrequently, difficulty in defæcation.

The duration of the disease varies; in the longest case hitherto observed the child died at six years of age. As a rule the diagnosis is made too late for radical treatment, but in two cases excision has been performed with good results; in one of these two cases the lower half of the posterior wall of the vagina was removed, and in the other the whole vagina and uterus were extirpated through a parasacral incision.

In the adult, sarcoma has been observed at all ages up to eighty-two. The tumour may be chiefly composed of round or of spindle cells with, not unfrequently, giant-cells, and frequently mucoid tissue. The disease usually appears as a circumscribed tumour, which may be situated in any part of the wall of the vagina. Occasionally the mass is polypoid; rarely it forms an annular constriction or even a diffuse growth which may narrow a large part of the vaginal lumen. The tumour may be entirely inside the vagina, or may present in the vulva. The symptoms, in addition to the presence of the tumour, are bleeding, discharge, and symptoms of pressure on the pelvic organs. The treatment consists in early and wide excision.

Carcinoma of the Vagina.—Carcinoma of the vagina may be secondary to disease of the cervix or body of the uterus, or to disease of the bladder or of the rectum. The vaginal affection may be due to direct extension of the growth, to contact infection, or to metastases through the lymphatics. Much less commonly carcinoma of the vagina is met with as a primary affection, and then it begins, as a rule, in the upper third of the posterior wall, close below the insertion of the cervix. The common variety of carcinoma met with is a squamous epithelioma. The disease usually forms a circumscribed tumour, only slightly raised above the surrounding surface, and when first recognised is almost always already ulcerating and breaking down on the surface, so as to form an irregular ulcer with hard infiltrated base and sharply-defined margins; the floor of the ulcer frequently shows fine papillary outgrowths of small roundish elevations. In the neighbourhood of the ulcer the mucous membrane is usually macerated by the discharges from the ulcer flowing over it, and shows signs of catarrhal inflammation with superficial erosions which easily bleed. Occasionally in the immediate neighbourhood of the ulcer there is thickening of the epithelium forming white, opaque, shining patches, which apparently represent a precancerous stage of the affection. Sometimes the proportion of new-growth to ulceration is greater, and the tumour may then form a mushroom-shaped projection more or less distending the vaginal lumen. In some cases, less frequently met with, the epithelioma infiltrates the whole or the greater part of the length of the mucous membrane, so that the vagina is transformed into a rigid, unyielding, and narrow tube. In all forms the glands are stated to be early implicated.

The growth extends along the surface, the cervix, especially the posterior lip, being early involved; sometimes the vulva is invaded, and then the inguinal glands may be affected. Extension also takes place deeply through the wall of the vagina into the para-vaginal tissue and upwards into the parametrium, as well as backwards round the rectum.

Epithelioma of the vagina is usually a disease of advanced life, but has occasionally been met with in women under thirty. In several cases the long-continued wearing of a pessary has preceded the appearance of the disease, and in a few instances it has arisen on a prolapsed vagina. The symptoms are the same as those of cancer of the vaginal portion of the cervix. The first symptom is always bleeding, especially on touch, and thus especially in sexual connection; wasting is often observed as an early symptom. Later in the history of the case come fœtid discharge and pain, and finally the cancerous cachexia, with frequently the formation of fistulæ, especially recto-vaginal. The diagnosis depends on the recognition of induration with peculiar superficial unevenness of the surface, and friability. Difficulty may arise in distinguishing the affection from sloughing myoma of the vagina, and from ulcers attended by some degree of proliferation, such as may be set up, for instance, by a badly fitting pessary. The prognosis is very grave, even after operation.

The treatment consists in the radical removal of the disease, when it is recognised sufficiently early. The removal has been carried out through the vagina, through the perineum, and by the sacral method. Olshausen's perineal method (*Cent. für Gynäk.* 1895, p. 1) is probably the best. In this the perineum is divided transversely, and blunt separation of the vagina from the rectum is continued as high as the bottom of Douglas's pouch; the peritoneum is opened behind the vagina and the uterus drawn down through the opening. The broad ligaments are then secured, beginning at the upper border and working down towards the side of the cervix. Finally, the anterior wall of the vagina is separated from the bladder.

In circumscribed tumours a partial excision of the vagina may suffice, but in all advanced cases the whole of the tube should, if possible, be removed. In women who still menstruate it is usually necessary to remove the uterus at the same time; in older women this is not so essential. Where the disease is already too far advanced for radical operation, treatment can only be palliative, and is carried out on the usual lines.

INJURIES OF THE VAGINA.—Accidental *wounds* of the vagina rarely are met with as the result of falls on to such objects as the leg of a stool or the point of a hay-fork. Occasionally lacerations are caused by coitus, but in such cases the injured vagina is the shrunken inelastic canal of an old woman, or is abnormally formed or altered by cicatrices. In criminal attempts at abortion, wounds are not unfrequently made, and in these cases the wound is usually in the posterior fornix behind the cervix. The injuries that are caused by labour are the most frequent and important class, and are considered separately (vol. vi. p. 294).

By whatever cause produced, wounds may give rise to serious hæmorrhage, which is, where possible, best treated by appropriate sutures, or, failing this, by packing with iodoform gauze. Many of the injuries are of importance only from the damage that is at the same time caused to neighbouring organs, the bladder, ureters, or rectum. In all wounds of the vagina there is risk of septic infection, to prevent serious consequences from which it is necessary to provide for adequate drainage.

Among the uncommon affections of the vagina may be mentioned *hœmatoma,* by which is meant hæmorrhage into the connective tissue surrounding the tube. This is extremely rare apart from pregnancy, and is due to an injury which causes no superficial wound or only a small one, while at the same time a vein or small artery is ruptured. A tumour forms in the course of a day or two, and is made up of blood, usually venous, partly fluid and partly clotted. The tumour is irregular in shape, has well-defined borders, and is not very tender; its consistence varies in different parts, is for the most part tense elastic, or may be fluctuating; the mucous membrane covering the tumour is livid and discoloured, and there may be a small breach of surface. The treatment of hæmatoma is in the first place expectant; if the tumour continues to increase in size an incision may be necessary, the clots being turned out and the cavity stuffed with gauze. At a later stage suppuration may take place, and a free incision is then demanded.

Foreign Bodies.—Foreign bodies may be introduced into the vagina for the purpose of mechanical treatment; thus pessaries are frequently left in the vagina, and may be neglected or even entirely forgotten by the patient. Not rarely objects are introduced into the vagina for the purpose of sexual gratification, either by the patient herself or by another person; bodies of the most varied and often surprising nature may thus be found, such as pieces of sponge, glass stoppers, spoons, drinking-glasses, hair-pins, and tobacco-pipes. A pessary properly constructed and applied, and made of a suitable material, and carefully supervised, may be worn by a patient for years without any evil effects arising. In some cases, but then usually only after the body has remained in position for some time, serious and even fatal consequences may ensue. By pressure a local ulcer may arise, which in turn becomes infected by germs and transformed into a spreading ulcer; the ulceration extends deeply into the surrounding tissue, and may even penetrate neighbouring organs, the bladder, the rectum, or a higher part of the intestinal tract, or even the peritoneal cavity. Bridges of connective tissue may form and imprison the foreign body, and polypoid growths of the cervix or vaginal walls may arise. Putrid and purulent discharges are common. After the removal of the body urinary or fæcal fistulæ may persist, and contraction of scar tissue may take place and give rise to stenosis or to complete atresia, and their consequences. In several cases carcinoma of the vagina has appeared to be caused by the long-continued irritation of a pessary.

Treatment is required to prevent evil consequences arising from the use of a pessary; this includes, besides the correct sort of material and form for the instrument, constant attention to cleanliness, and regular supervision by the physician, who should remove and examine the pessary once in every two or three months; any pain or irritation should lead to a prompt examination. The treatment of neglected cases consists in the removal of the foreign body, a proceeding often giving rise to much difficulty and anxiety; in counteracting the evil effects that have arisen from the presence of the body; and in the attempt to prevent injurious contraction of the resulting scar tissue.

Acquired Stenosis and Atresia of the Vagina.—In their effects, symptoms, and treatment, these conditions present many points in common with the congenital affections of the same name (vol. iv. p. 152).

It is probable that many of the so-called congenital cases are really acquired either during intra-uterine life or in childhood. In the adult the chief source of these conditions is severe labour and its consequences, especially septic infection supervening on breaches of surface and leading to extensive ulceration or even gangrene of the vagina. Sometimes constriction is set up by other causes, as for instance by foreign bodies, the application of strong caustics to the cervix or vagina either for legitimate medical treatment or by criminal abortionists, or it may be due to septic infection of operative wounds on the vagina.

As a result of some of these causes scars of varying thickness and extent are found in the vagina. These may take the form of longitudinal bands, frequently extending upwards from the neighbourhood of the pubic ramus; or they may be present as semi-lunar folds or as complete rings round the vagina giving rise to annular stricture. The lumen may be almost completely occluded by a thin membrane with a small opening through which a fine probe passes with difficulty, or it may be reduced to a more or less narrow canal by a broader scar surrounding it for some distance. Complete atresia may similarly be due to a thin membrane or to a scar several centimetres in thickness, or finally the whole tube may be completely destroyed.

Urinary Fistulæ.—Urinary fistulæ may be caused by the misuse of instruments, such as blunt or sharp hooks, in effecting delivery, or more frequently by pressure necrosis in severe cases of obstructed labour. Sometimes the vesico-vaginal wall is perforated by foreign bodies such as ill-fitting pessaries or by stone in the bladder. Of recent years a prolific source of urinary fistulæ has been the great increase in the number of operations on the genital organs, and especially of total extirpations of the uterus.

The position of the fistula varies. The most common form is the vesico-vaginal fistula where the bladder is affected; this may extend so far downwards as to implicate the vesical opening of the urethra, or so far upwards as to involve the cervix. The urethra alone may be affected (urethro-vaginal fistula); the fistula may involve the cervix, either along with or independent of the vagina (cervico-vesical fistula and cervico-vagino-vesical fistula). Uretero-vaginal fistulæ are also far from rare, especially as the result of vaginal hysterectomy.

Urinary fistulæ are usually single, but occasionally more than one is present. The vesico-vaginal form is the most frequent; its borders may be sharp and well-defined, or may be thickened and sometimes widely surrounded by scar tissue. In size the fistula may vary from an orifice so small as to admit a fine probe with difficulty to the size of a threepenny piece or a florin, or even larger. Sometimes in large fistulæ laterally situated the ureter is found opening in the wall.

Cervico-vesical fistulæ affecting the upper part of the cervix are always small. Uretero-vaginal fistulæ appear either as small clefts with sharp edges or as openings on small elevations; those arising from labour are found near the side of the cervix in a depression running outwards from the external os or a little behind this level. In these fistulæ the vesical end of the ureter frequently tends to become obliterated. In the puerperium urinary fistulæ usually become much smaller, and the process of contraction continues until the borders are covered with epithelium. Affections of the upper urinary tracts—dilatation of the ureters, pyelitis, stone in the kidney, abscesses, and so on—are not infrequently met with, especially in fistulæ of some standing, and are of great importance as influencing the prognosis, especially where operation is contemplated. Amenorrhœa is frequently observed, and menstruation first returns after a successful plastic operation.

In vesico-vaginal fistulæ the whole of the urine dribbles away as it is formed, though it is not uncommon for a certain amount to be retained so long as the patient lies on the back. In uretero-vaginal fistulæ half the urine dribbles away from the vagina, and the other half is passed naturally by the urethra. It is sometimes difficult to decide whether a patient with incontinence of urine is the subject of a urinary fistula or not, and in these cases the injection of a coloured fluid, such as milk and water in equal quantities, into the bladder, while at the same time the vagina is carefully observed through a Sims' speculum, easily enables a diagnosis to be made.

The treatment of vesico-vaginal fistulæ consists in a plastic operation, to which there are practically no contra-indications. In exceptional cases where the closure of the fistula itself is impossible, the closure of the vagina below the seat of the fistula, or closure of the vulva, is performed, but in nearly every case the plastic operation is carried out on the fistula itself. The best time for the operation in a case arising after parturition is 6 to 8 weeks after labour, at a time when the lochia has ceased, and the tissues are still vascular, but sufficiently firm to hold sutures. Attempts to close the fistula by means of cauterisation, as, for instance, by the actual cautery, nitrate of silver, chromic acid, caustic potash, and the like, have frequently been made; these attempts are useless and harmful except in the case of small fistulæ with edges still granulating, such as are seen soon after labour, or after a plastic operation where there is a little leaking in the line of union, or along a suture; in such cases the application of nitrate of silver is sometimes useful.

In all ordinary cases plastic operation on the fistula itself, by the preparation of raw surfaces and the application of sutures, is the method to be employed. In many cases a preparatory course of treatment is necessary to get rid of complicating irritation and inflammation, especially where these are due to the flow of alkaline putrid urine, which at the same time precipitates lime salts on the raw and inflamed surfaces; here bland demulcent drinks, the frequent use of irrigations to which some mild antiseptic is added, and the administration of a mixture containing oil of turpentine, salol, or urotropin, are useful. Where there is much cicatricial contraction of the surrounding tissues Bozeman recommended that a preparatory dilatation should be undertaken by means of glass bottles, rubber plugs, or cylinders, and incisions, but the scars may be much more advantageously dealt with by the knife and speculum in the first stage of the plastic operation.

The operation may be described as consisting in three stages. The first stage consists in rendering accessible the fistula, the second in preparing the raw surfaces, and the third in applying the sutures.

First Stage. The patient is placed in the lithotomy position; occasionally the semi-prone or the knee elbow position may be found preferable. The usual preparatory cleansing is made, and the fistula is then rendered accessible by some modification of the Sims' speculum and by lateral vaginal retractors; the uterus may be pulled down by a volsella, or the edges of the fistula may be made prominent by a catheter passed through the urethra, or by a sponge held in forceps and passed through the fistula into the bladder. The urethra, which is always contracted in fistulæ of any standing, should be dilated. Bands of scar tissue may be stretched by the pressure of speculum and retractors, or an incision may be made through their thickness. In stenosis of the vagina it is often most difficult to expose the fistula properly, especially where it is adherent by scar tissue to the back of the pubes; in such cases the tissues surrounding the fistula may be loosened from the bones by an incision made external to the labium majus and carried down to the ramus of the pubes, or it may even be necessary to make an incision above the symphysis pubis, and in that way detach the borders of the fistula.

Second Stage. A raw surface may be obtained either by denudation or by the flap-splitting method. The important points to aim at are that the raw surfaces shall be sufficiently broad, that they shall come together without tension on the sutures, and that they shall be free from scar tissue and bleed freely. A denudation may be narrow, as in Simon's method, where an incision is made all round the borders of the fistula, embracing the whole thickness of the wall, vesical as well as vaginal; or it may be wide as in the so-called American method, where the vesical wall is not touched, but a broad strip, half an inch or more in width, is removed from the vaginal wall all round the orifice of the fistula. In any case it is best to first mark the outer border of the flap proposed to be removed by the scalpel; afterwards the flap may be cut off by means of either scissors or sharp-pointed scalpel, the borders being held taut by fine sharp hooks or by hook forceps. If the ureter is present in the wall of the fistula it must be preserved.

The method of preparing raw surfaces by flap-splitting presents many advantages. In it the wall of the bladder and that of the vagina are separated from each other for the required distance all round the fistula, and the two walls are then sutured separately. There is no loss of tissue, and if the operation fails the conditions for the next attempt are no worse; a very broad surface can be obtained for suturing, and, further, the sutures can be applied with much less danger of tension.

Third Stage. The sutures may be applied by means of handled needles with suitable curves, or by small curved and half-curved needles with a needle-holder. The material employed may be silver wire, silkworm gut, or fine silk. Deep sutures at intervals of about a quarter of an inch should be passed under the whole width of the raw surface and brought out near its borders; all the sutures should be placed before any are tied. The direction of the line of union is often determined by the shape of the fistula or of the freshened surface; where there is a free choice a transverse line is preferable, because then there is less risk of tension on the sutures; in large defects the union will often not be in a single line, but will have a Y or T shape. After all the sutures are introduced, the wound is sponged dry, and the sutures are tied. Finally the bladder is washed out to remove any blood that may have entered and to make sure that the closure is perfect.

Where the flap-splitting method has been employed, the vesical wall is brought together by one or more layers of interrupted catgut sutures, the vaginal wound being then closed by silk or wire or silkworm gut sutures.

The after treatment is simple. The wound is powdered with iodoform at the close of the operation, and is then left completely at rest until the sutures are removed; only if there is some special indication are vaginal douches needed. The catheter is passed every two or three hours until the patient is able to pass urine naturally, which she is allowed to do as soon as she is able. Ten days is the usual term for complete rest in bed; an easily digestible diet should be ordered, and daily evacuation of the bowels secured. Silk sutures may be removed on the eighth or ninth day; wire or silkworm gut may be left for a week or two longer. The failure of the operation is marked as a rule by irregular rise of temperature, or by some incontinence making its appearance again on the third or fourth day. Sometimes, however, the failure is not discovered until the patient is allowed to get up or the sutures are taken out. The cause of the incontinence may now be a stitch hole, which will heal up with a few days' extra rest in bed, or after a few applications of nitrate of silver. If the operation has to be repeated, this should be done two to three weeks after the first one.

Recto-vaginal Fistulæ.—Sometimes after labour a complete rupture of the perineum may be followed by a superficial healing which leaves a communication between the rectum and the vagina, and the same result occasionally follows badly executed plastic operations for complete rupture. Fistulæ may also arise from partial gangrene during the puerperium, from long-continued pressure from a pessary, especially Zwanck's, or occasionally from a wound. Finally, recto-vaginal fistulæ are also found in advanced cases of malignant disease of the cervix, vagina, or rectum, and in the group of affections which are included under the name ésthiomene.

Fistulæ between the vagina and the large intestine above the rectum, or between it and the small intestine, are also occasionally met with. They are always situated high up in the posterior vaginal wall, and may arise either as a result of a vaginal rupture in labour, which allows coils of intestine to protrude, or as a result of a fall on a sharp penetrating object, such as a hay-fork. Occasionally a fistula of this kind may arise indirectly from an abscess in Douglas's pouch, usually the result of a salpingitis, opening into the vagina and the rectum; the abscess may be tuberculous. In these cases of intestino-vaginal fistula, either the whole contents of the bowel may pass through the fistula—an artificial vaginal anus; or only a part may pass, in which case the term intestino-vaginal fistula is appropriate.

The symptoms vary with the size of the fistula. In very small openings there may be a valve-like closure and no symptoms; in other cases flatus and fluid motions pass through the fistula, and in still larger ones most of the evacuations may pass through the fistula and thus through the vulvar orifice. The symptoms of a communication between the vagina and the small intestine consist in the passage of the characteristic contents of the small intestine at a longer or shorter interval after meals. Where all the contents of the small intestine pass through the vagina the general condition of the patient rapidly deteriorates, and on this circumstance, as well as on the cause of the fistula, the prognosis depends. Where only the smaller portion of the contents pass through the vagina, the fistula shows a great tendency to heal spontaneously, although the process of healing may take a very long time. It is important to bear this in mind, because it follows that operation should not be undertaken too hurriedly in these cases. Where there is an artificial anus the best treatment probably consists in laparotomy and separation of the adherent and fistulous intestine, followed by sutures or by anastomosis as may be indicated. Where the fistula depends on tubercular disease it is best left alone.

The prognosis of recto-vaginal fistula is the same as that of the condition which gives rise to it. The treatment in simple cases consists in plastic operation. This is usually carried out through the vagina, and comprises two steps: (1) the preparation of a raw surface, and (2) the application of sutures. The raw surface may be obtained either by denudation of a strip of vaginal mucous membrane bordering the fistula; or by a process of flap-splitting, the vaginal wall being separated from that of the rectum for a sufficient distance all round the margin of the fistula. In the second step of the operation sutures are introduced; in the case of denuded surfaces one row of interrupted sutures is applied, the material employed being silkworm gut, wire, or silk. Where the flap-splitting operation is chosen the rectal orifice is usually closed by a layer of buried catgut sutures, and the vaginal wound is then brought together by interrupted silk or silkworm gut sutures. The method of flap-splitting has the great advantages that by it no tissue is lost, and that there is less chance of tension on the sutures. When the fistula is small and situated at the lowest part of the vagina, just above the perineal body, it is best to split the perineum and to operate in the way that is usual for this condition. The after treatment in all cases is just the same as that following the operation of perineorrhaphy.

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Vagus Nerve.

The vagus, pneumogastric, or tenth cranial nerve, is a mixed nerve, with a very wide peripheral distribution.

Anatomy.—The vagus nerve is intimately associated with two nuclei in the medulla oblongata.

The *dorsal nucleus,* to which a large portion of the vagus trunk proceeds, lies beneath the floor of the fourth ventricle, immediately external to the hypoglossal nucleus and internal to the nuclei of the posterior columns. The prominence on the floor of the ventricle which is known as the ala cinerea marks the position of this nucleus. A large portion of the glosso-pharyngeal nerve terminates in the same group of cells, which is for this reason commonly called the vago-glosso-pharyngeal nucleus.

The dorsal nucleus of the vagus is generally looked upon as having a sensory function, although some writers hold that motor fibres also arise from it.

Some of the vagus fibres take origin from a smaller mass of grey matter which lies ventral to the nucleus above mentioned and detached from it. This is the accessory vagal nucleus, or *nucleus ambiguus.* The seventh nerve and some fibres of the glosso-pharyngeal arise from an upward prolongation of the same group of cells, while from its downward continuation into the spinal cord the eleventh nerve takes origin.

The nucleus ambiguus is regarded by the majority of recent writers as the motor nucleus of the vagus. Marinesco is of opinion that the fibres which supply striped muscle arise from this nucleus, while those innervating non-striped muscle originate in the dorsal group of cells.

A small part of the entering vagus root has been traced into the *fasciculus solitarius,* a compact bundle of fibres which lies external and slightly anterior to the dorsal nucleus. This bundle also contains glosso-pharyngeal fibres. It passes caudally, and gradually splits up into end ramifications, which terminate in the adjacent grey matter of the medulla. The fasciculus solitarius is sometimes known as the ascending vago-glosso-pharyngeal root.

The fibres from the nucleus ambiguus pass for a short distance backwards; they then turn forward at an acute angle, those from the anterior part of the nucleus joining the fibres passing from the dorsal nucleus to form the common vagus trunk, while those which arise posteriorly after leaving the brain unite with the nerve of Willis to form the spinal-accessory.

The ninth, tenth, and eleventh cranial nerves pass together through the jugular foramen.

Function.—The vagus has a very wide distribution, supplying muscle, skin, and viscera. It is distributed to the pharynx, larynx, heart and lungs, œsophagus, stomach, and in part the intestine. A small branch innervates the skin of the external auditory meatus.

Lesions.—The nerve may be involved by lesions within the medulla, at the base of the brain, or in its peripheral course outside the cranium.

The nuclei, or the intramedullary fibres proceeding from them, may be damaged or destroyed by hæmorrhage, acute inflammatory conditions, softenings due to arterial occlusion, tumours, or chronic degenerative processes. Various affections of the meninges, especially syphilitic meningitis and meningeal hæmorrhage, may damage the nerve trunk in its intracranial course. In this situation the nerve may be pressed on by a tumour, or more rarely by an aneurysm of the vertebral artery. In its peripheral course the vagus may be implicated in a tumour, and it is sometimes divided by the surgeon, or included in a ligature when the carotid is tied. A neuritis has been met with after a number of the infective fevers, more especially diphtheria, while alcohol and, in rare cases, arsenic and lead, may act as the determining factor of the morbid process.

The recurrent laryngeal nerve is very frequently involved in cases of aneurysm and intrathoracic new growths.

Symptoms.—The vagus has a very extensive distribution, and the symptoms produced by a lesion affecting it are necessarily widespread and various. They depend largely upon the site of the lesion. Complete paralysis of the whole trunk is not uncommon where the nerve is involved at the base of the brain. The ninth, twelfth, and upper part of the eleventh nerves are usually involved at the same time in the case of lesions in this situation. Unilateral paralysis of the palate, larynx, and tongue, with difficulty in swallowing, is a typical combination of symptoms produced by such intracranial lesions. Injury to the nerve high up in the neck is often attended with the same symptoms. In such a lesion the tongue escapes, and difficulty in swallowing is not usually pronounced.

Increase of the pulse-rate is commonly present; the respirations are sometimes increased; more rarely both the rate of the pulse and respirations are diminished. These cardiac and respiratory symptoms are usually not pronounced unless both nerves have been injured. Pneumonia has occasionally followed division of the vagus. Vomiting, gastric pain, loss of hunger and thirst, which have been observed, are attributed to involvement of the gastric branches. As has been already stated, paralysis of the recurrent laryngeal nerve is frequently met with. This nerve curves around the arch of the aorta on the left side and the subclavian artery on the right. It supplies the mucous membrane of the larynx below the vocal cords, and all the muscles of the larynx except the crico-thyroid, which is supplied by the superior laryngeal.

In consequence of pressure on the nerve, unilateral abductor paralysis is frequently met with. Where this is the case the voice is somewhat hoarse, and there is no movement of the corresponding cord on inspiration. There is seldom much dyspnœa. The adductors often become affected at a later date, when the loss of voice may be pronounced.

In cases of bilateral abductor palsy the voice is little changed, but inspiration is difficult, and associated with a loud stridor.

Bilateral adductor paralysis is common in hysteria. There is an inability to approximate the cords, and, in consequence, a condition of aphonia. When the patient attempts to speak the cords remain in the position of abduction. There is no stridor or dyspnœa.

In cases of total bilateral palsy both cords are moderately abducted and motionless, there is complete aphonia, the patient cannot cough, and there is stridor only on deep inspiration.

The *treatment* in cases of paralysis of the vagus nerve must be directed to the cause of the paralysis.

Varicella.

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SYNONYMS.—*Latin*, Varicella; *English*, Chicken-pox; *French*, Varicelle, variolette, fause vérole, vérole bâtarde, petite vérole volante, pustules de poulet, nasles; *German*, Windpocken, Wasserpocken, Varicellen, Schafblattern, Spitzblattern, Falsche Pocken; *Italian*, Varicella, Morviglione.

Some of these names indicate that the disease was formerly regarded as a minor form or variety of *variola* or small-pox.

DEFINITION.—A very infectious disease, occurring chiefly in children, attended by little constitutional disturbance as a rule, and displaying on the first day an eruption of small red papules, which are soon converted into watery vesicles—the vesicles ultimately drying up, and giving place to small crusts.

Etiology.—The disease is doubtless spread by a *contagium* derived from a previous case of the disease. Personal contact, or *fomites*, will convey the contagium.

Up till the present time, so far as the writer is aware, no specific organism has been identified in the disease. Attempts at inoculating chicken-pox have been attended with doubtful or unsatisfactory results. The possibility of doing so may be regarded as an open question.

Symptomatology.—The period of incubation is variously stated, but the writer puts it at thirteen days (for convenience say a fortnight).

Thomas gives thirteen to seventeen days, Trousseau (1) fifteen to twenty-seven days.

The following may be taken as a description of an ordinary attack of chicken-pox. At the end of a fortnight, dating from the time of exposure to the contagium, the patient feels "out of sorts"—perhaps there is loss of appetite, some giddiness, headache, or slight pain in the back. As a rule there is little or no elevation of temperature, but in cases with a profuse rash there may be very considerable pyrexia.

In many, perhaps most, cases of chicken-pox there are no prodromata.

The rash appears *on the first day* in the form of small red papules.

The spots appear on the chest, back, and limbs. There may be a few on the face, and they frequently occur on the scalp, where they are more easily felt by the patient than seen by the physician. The spots are converted into vesicles in the course of a day or so, and then present the appearance of little blisters or sacs, with clear watery contents, and each is surrounded by a red areola.

It is worthy of note that the eruption of varicella occurs on the mucous surfaces as well as on the skin. It is found in the mouth, on the throat, etc. The contents of the vesicles become milky or opalescent, and in a few days more are converted into little scabs or crusts. When the drying stage commences there may be flattening or dimpling of the top of the vesicles. On removal these crusts leave behind them marks or stains which subsequently disappear, but in some cases permanent pits or cicatrices are left. This latter result is, however, exceptional. It is most likely to result from premature removal of the scabs by scratching, and the consequent formation of small ulcers which, on healing, leave scars. It must be admitted, however, that in some cases pits are left where there has been no mechanical irritation. In such cases the bed of the vesicle, being deep, has involved the true skin. It has been the custom to state that the vesicle of varicella is unilocular, while that of variola is multilocular, and this has been regarded as one of the means of distinguishing between the eruption of chicken-pox and that of small-pox. This view is not tenable in the light of our present knowledge.

The statements of Unna (2) on this point are so clear and precise that one cannot do better than quote his exact words:—"I take the description of the eruption from a characteristic 'chicken-pock' which I excised from an eight-year-old boy on the second day of its existence. I choose this because it gives the most perfect contrast to the centrally depressed variola vesicle, for in it the most central point of the surface is the most elevated. It has a tent form. The lateral walls rise obliquely from a broad base towards the centre of the covering, which is formed by a few stretched, horny scales. From these cellular partitions radiate downwards as in small-pox. The chicken-pock is consequently divided like the small-pock, but the point where the septa join lies here, not in the centre of the base of the pock, but on the covering." And again at p. 639 (under *Variola*) he says, "The main character which distinguishes the vesicular formation in true small-pox (variola, varioloid) from that in chicken-pox, consists, on the one hand, in the slow growth, on the other, in the prompt addition of suppuration to the fibrinoid degeneration, which obscures the effects of the latter."

If the reader wishes a detailed and particular account of the pathological changes which bring about the formation of the varicellar eruption he is referred to the volume just quoted, in which will also be found plates illustrating the points in question. The eruption of varicella may continue to come out in *successive crops* for a considerable time. The fresh crops may be accompanied by elevation of temperature.

There are no *complications* to be noted in varicella, and there are, perhaps, no real *sequelæ* to be dealt with. It is true, however, that in dirty and unhealthy children the sores which originate in the picking and scratching of the vesicles may give rise to troublesome consequences.

Sir Dyce Duckworth, in his Lumleian (3) *Lectures on the Sequelæ of Disease,* says: "Varicella has no true sequels in respect of changes which may occur in the rash. Prurigo may result, so-called varicella prurigo (Hutchinson). Ecthymatous sores resembling pemphigus are sometimes met with. The vesicles may become gangrenous in delicate or tuberculous children, and the result is probably due to the supervention of extraneous microbic infection, and not to the influence directly of varicella poison. Like the eruptive fevers, varicella may be followed by pertussis, a lowered condition of health paving the way for fresh infection, with increased susceptibility to it."

With regard to the gangrenous affection it may be said that it consists in the formation of sloughs which, on separation, leave deep ulcers. The ulcers may coalesce. When this morbid action is extensive there is pyrexia, while "lung complications, tubercular, pyæmic, or inflammatory, are very frequent, and determine or hurry on the fatal issue" (H. Radcliffe Crocker (4)).

For illustrations of pruriginous impetigo (following varicella) *vide Atlas of Skin Diseases,* New Syd. Soc., plate xxxii.

DIAGNOSIS.—The diagnosis of chicken-pox is, as a rule, easy—*especially when the eruption is in the stage of clear watery blebs.*

The differential diagnosis between *small-pox* and *chicken-pox* is a matter of very great importance.

In the great majority of cases the distinction between the two diseases is made without any difficulty.

It must be honestly confessed, however, that (if the case is seen in the crusted stage, and with only a few spots, and without any clear history) there may be great doubt between chicken-pox and a mild or abortive attack of modified small-pox.

Some slight cases of varioloid have little constitutional disturbance, and only a few spots—spots which may be easily overlooked, or if seen in the crusted stage, may be mistaken for chicken-pox. In such exceptional and doubtful cases much assistance will be obtained if the patient can be *associated* with previous cases of chicken-pox on the one hand, or small-pox on the other.

The following scheme presents in contrast the salient features of variola *versus* varicella, but, like many other elaborations of the study, it may sometimes prove unsatisfactory by the bedside.

SMALL-POX	CHICKEN-POX
Prodromata severe	*Prodromata slight or absent*
Heavy sickness, severe pain in back, vomiting.	*Perhaps* slight headache, pain in back, shivering.
Spots come out on 3rd day. Spots come out in progressive order from above downwards—face, hands and arms, trunk, legs, feet.	Spots come out on 1st day. Spots come out in successive crops, the new spots being widely distributed.
Temperature: three days' pyrexia at onset, and pyrexia again when suppuration occurs, about the 9th day (called the secondary, or suppurative fever).	Temperature not high as a rule. But pyrexia accompanies each fresh crop of spots if the eruption is profuse.
Liable to have very grave complications and sequelæ.	Neither complications nor sequelæ to be reckoned with, as a rule.
The centre of the vesicle is depressed.	The centre of the vesicle is the highest point.
Eruption apt to leave pits, often deep and permanent.	Pitting occasional, and slight as a rule.

Dr. Wanklyn (5) deals with the diagnosis between variola and varicella in a very able way: he does not attach much weight to "history"; the terms "shotty" and "umbilication" he would dismiss as unreliable indications. He attaches great importance to *distribution* of the rash, which in small-pox abounds on face, wrists, hands, and feet frequently; while in chicken-pox the trunk is the favourite field. In some cases of varicella there may be abundant eruption on the face, but not on the forearms and hands or lower extremities. Dr. Wanklyn's article is worthy of careful attention.

Chicken-pox and small-pox are separate and distinct diseases.

Chicken-pox gives no protection against small-pox, and small-pox gives none against chicken-pox.

Vaccination gives no protection against varicella.

It is sometimes stated (as a point of differential diagnosis between variola and varicella) that while small-pox spots are found on mouth, or palate, or throat, chicken-pox spots are never found in those situations. The statement is not correct. The varicella eruption may also be found in these localities. A difficulty in diagnosis may arise between chicken-pox and some skin diseases, such as eczema pustulosum and impetigo. As regards impetigo, it is stated that the eruption may be distinguished by its pustular character—the absence of red areola—and the fact that the rash has not the wide distribution of chicken-pox.

Unna (2, p. 552) describes a *varicelliform syphilide*, which he says "is very rare."

Dr. R. S. Thomson (6) has described a disease occurring in Lascars which in some points resembled small-pox and in others chicken-pox. He concludes that it is neither, but a separate disease. He refers to similar cases recorded in Jamaica more than thirty years since by Dr. Isett Anderson. The subject is one of much interest.

It is to be borne in mind that varicella may manifest itself at the same time as measles or scarlet fever.

Dr. Webber records a case of "concurrent eruption of measles and chicken-pox" in *Lancet*, 5th Nov. 1898.

Trousseau states, on the authority of Dr. Delpech, that a child had small-pox and chicken-pox together.

PROGNOSIS is good. The disease is not a dangerous one. It is popularly regarded as a very trifling ailment.

It is to be borne in mind, however, that varicella is sometimes attended by pretty severe symptoms.

The writer has seen children with marked pyrexia, pronounced constitutional disturbance, and in misery.

And in delicate and unhealthy children we must not lose sight of the possibility of further trouble in the shape of prurigo—ulceration and gangrenous sloughing.

The PATHOLOGY of this disease is very meagre. As death from uncomplicated chicken-pox is practically unknown, opportunities for investigation do not occur.

TREATMENT.—The treatment of an ordinary case may be comprised in warmth, slop diet, attention to the bowels, and, perhaps, the administration of a diaphoretic.

RELATIONS TO PUBLIC HEALTH. PREVENTION.—As varicella is not a fatal disease it might be considered unworthy of the attention of sanitary authorities. This, however, is far from being a correct view. All cases of chicken-pox should be made known to the medical officer of health, because *a mild case* of small-pox may be mistaken for chicken-pox, and so escape the control which is necessary for the public safety. This danger is not an imaginary, but a real one. "It is stated that the Chicago case, which was the starting-point in Montreal of the epidemic of 1885, was regarded as varicella, and not isolated. If so, the mistake was one which led to one of the most fatal of modern outbreaks of the disease" (*Osler*). Cases of varioloid, if seen in the crusted stage, and with only a few spots, are liable to be passed over as varicella, especially if the patients deny having felt ill, and cannot be *associated* with small-pox cases.

Varicella may prevail in epidemic form, and, although not dangerous, may give rise to much trouble and disorganisation in schools, hospitals, nursing homes, etc.

The writer can recall annoying experiences from outbreaks of the disease occurring in the wards of a fever hospital. When cases cropped up in measles, scarlet-fever, or whooping-cough wards, no end of trouble and worry was the result. The children who took the disease in hospital could not be sent home till all the crusts were off, and those who did not take it had to be detained for a fortnight at least (incubation period) before being dismissed.

And how did such outbreaks originate? A child admitted with measles or scarlet fever might have a few little scabs among the hair which unfortunately were not immediately recognised as chicken-pox crusts, the result being the infection of the ward, with fresh cases cropping up in a tantalising fashion one or two at a time with a fortnight's interval. This might go on for months till all the susceptible children had taken the chicken-pox. The disease seemed to increase in severity in the successive cases, as if the virus gained in intensity.

The writer has also seen the work of a surgical nursing home totally disorganised, and heavy expenditure incurred, all through the occurrence of chicken-pox in a patient who was admitted to the institution in the incubation stage.

PREVENTION.—The measures taken to prevent the spread of small-pox are applicable to varicella.

The patient should be isolated in a bare room with a special nurse.

When all the crusts have separated he should have several warm baths, and get a complete suit of fresh clothing before regaining his liberty. Crusts among the hair must not be overlooked.

The sick-room should be washed down and repapered, while all clothing and bedding should be disinfected, either by steam or boiling. While the patient is under treatment it is a good plan to put all soiled linen at once under a disinfectant solution (*e.g.* carbolic acid and water).

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Varicocele. *See* SCROTUM.

Variola. *See* SMALL-POX.

Veins, Diseases of.

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1. ANATOMY AND PHYSIOLOGY

THE wall of a vein, like that of an artery, is composed of muscular and elastic tissue, lined internally by a pavement membrane, and strengthened externally by a layer of connective tissue.

The inner coat (intima) consists of a layer of flattened cells which is continuous with the lining walls of capillaries, and is supported by a small amount of elastic tissue which seldom forms a complete membrane. The middle coat, which contains much less muscular tissue than that of an artery, consists of bundles of white connective tissue, some elastic tissue, and bundles of circular muscular fibres. These circular muscular fibres are almost entirely absent in the superior vena cava and in the upper part of the inferior vena cava, and in some veins there are some longitudinal muscular fibres. The outer coat is composed of fibrous tissue stronger than the corresponding coat in arteries.

Valves.—Many veins possess valves, which are semilunar folds of the internal coat, containing a little fibrous tissue, and each valve consists usually of two cusps opposite one another.

There are no valves in most of the veins of the viscera, nor in those within the cranium or vertebral canal and bones, nor in the umbilical vein.

There is no muscular tissue in the walls of the veins of the pia mater, brain or cord, bones, nor in the venous sinuses of the dura mater or placenta. The walls contain vasa vasorum, nerves, and lymphatics.

Venous Systems.—Clinically it is useful to recognise certain great divisions of the venous system, along any one of which the effects of back pressure from an impaired heart may be evident, or which may be affected by pressure.

Such are—

(1) Superior vena cava system.
(2) Inferior „ „ „
(3) Pulmonary venous system.
(4) Portal „ „

The two former possess valves on their branches, the first from the heart outwards being found an inch from the lower end of the internal jugular vein, in the subclavian vein beyond the entrance of the external jugular, and in the external iliac veins, there being no valves in the internal iliac veins.

The two latter, the hepatic veins opening into the inferior vena cava, and the pulmonary veins opening into the left auricle, have no valves, and therefore it is along these systems that the effects of back pressure from the heart are first evident, from the right and left auricles respectively.

The coronary system possesses valves which may be incompetent.

Venous Flow.—Alterations in the venous flow are so frequent and so evident that it will be well to point out the causes to which this flow is due. They are the *vis a tergo* of the circulation, the aspirating effect of the heart, and muscular action compressing those veins which have valves.

Venous pulse may be observed when the arterioles are so dilated that the arterial pulse passes through the capillaries to the veins, and in the superior and inferior vena cava near their entrance to the heart, due to variations in the pressure in the right auricle, as in tricuspid incompetence, and also to respiratory movements.

THROMBOSIS AND PHLEBITIS

Thrombosis (θρόμβος, a clot); Synon.: Fr. *Thrombose;* Ger. *Thrombose.*
Phlebitis; Synon.: Fr. *Phlébite;* Ger. *Venenentzündung.*

Definition.—Thrombosis is the formation of a clot or coagulum of fibrin in the heart or vessels during life. Phlebitis is inflammation of the coats of a vein.

These two conditions are closely related to one another, and clinically are usually found together. When a thrombus forms in a vein the irritation produced by its presence sets up a phlebitis, and phlebitis is accompanied by thrombosis of the vessel when the inflammation spreads to the inner coat of the vein, since the inflammation causes coagulation of the contents of the vessel.

Ætiology of Thrombosis.—The coagulation of blood, consisting in the formation of fibrin, is brought about by the action upon the fibrinogen of the serum of a fibrin ferment produced by the destruction of leucocytes and from blood platelets. Clinically, it is essentially the result of stagnation of the blood stream, together with some other cause which can bring about the formation of the fibrin ferment.

Such causes may be found in the vessel wall or in the blood itself.

Among the first any injury or contusion, or laceration, or the exposure of the vessel in a wound, or any inflammatory or degenerative change in the wall of the vessel, may cause thrombosis; but the factors in this class are of less importance from the point of view of treatment than those of the second class which include the cause usually determinable in an ordinary and uncomplicated case of thrombosis.

The hæmic conditions may be described generally as any condition which affects the physiological integrity of the leucocytes, as thereby there is a tendency for the liberation of the fibrin ferment. We may include in this group all cases from those in which the patient is suffering from an actual septicæmia or pyæmia, to even that less virulent form which can only be described as a "gouty" condition, and including those in which there is a general condition of exhaustion, and in this last variety there is an added tendency from the slowing of the blood stream. The tendency in any of these cases is increased by any local or general interference with the circulation, such as a weak heart, loss of the elasticity of the arteries, by the compression of a tourniquet or a tight bandage, or by pressure from a tumour.

The combined action of these two causes is exemplified in the thrombosis which occurs in the later stages of exhausting diseases, such as phthisis, typhoid fever, or prolonged suppurative conditions. This effect of slowness of the blood stream is in part due to an alteration in the state of the endothelial cells, which are ill-nourished when the blood that bathes them is not renewed with the usual rapidity.

Toxic materials or parasites in the blood stream frequently determine thrombosis. In malaria the parasites actually plug the small vessels of the brain and spinal cord, and in pyæmia and septicæmia the organisms have a direct coagulating effect on the blood.

Pathology.—Following upon such conditions a clot may form in a vein, and usually extends for some distance along the vessel, or at least to the point where the vein joins another one.

At this point the thrombus is liable to be broken, and part to be carried off in the blood stream, forming an embolus. The thrombus adheres to the vessel wall, and if the circulation be active the red corpuscles and the colouring matter are washed out, and the clot is of a pale colour or white thrombus, while if the colouring matter remains a red thrombus is the result.

The next stage in the process is that an inflammatory change is produced in the vessel wall, and a series of changes ensues, the same as those found in an artery (*q.v.*), with the result that the thrombus becomes organised, and thereby converted into a fibrous cord which may permanently block the vessel, or may in part be absorbed, with the result that the lumen is restored to a certain extent.

Other changes which may subsequently occur are—

1. Calcification, consisting in a deposit of lime salts in the thrombus, and resulting in the formation of a phlebolith, a small round and hard nodule frequently met with in varicose veins.

Phleboliths are formed from the salts present in the blood, and consist, like bone, mainly of phosphate of lime, with the sulphates of lime and potash. They are commonest about the base of the bladder in varicosities of the prostatic plexus and in nævi in which thrombosis has occurred.

2. Simple disintegration may apparently occur, a change in which the thrombus is gradually broken up, and the fragments carried off in the general circulation without any bad effects.

3. Embolism and septic or infective softening of the thrombus are serious complications, the occurrence of which entirely alters the character of an apparently simple case, and which must always be borne in mind.

Septic or infective softening is due to the action of micro-organisms, which may have formed the original nucleus of the thrombus or may reach the clot when it has been formed from the vessel wall, as in cases of septic phlebitis.

As the result of their action the thrombus is broken down into a soft pulpy mass, around which further thrombosis may occur, and so prevent the access of the infective material to the general circulation. If the softening proceeds with greater rapidity than this protective clotting, the broken-down particles enter the circulating blood, and are carried to the right side of the heart and to the lungs, producing secondary thrombi there and in other parts, which again break down and form abscesses.

Effects of Thrombosis.—These depend upon the situation and size of the affected vessel. In small veins the difficulty in the return circulation is soon overcome by the blood finding its way by collateral channels; but when there is important interference, the result is œdema of the distal part of the limb, which may be severe and persistent, and even lead to moist gangrene of the limb. In the lower limb the œdema usually commences about the ankle, and spreads upwards to the point of obstruction. As the œdema increases the veins become obscured in it, and may be felt as gutters or grooves in a solid mass of tissue. There is at first a sensation of stiffness or tightness in the part, and later weakness of the muscles and heaviness and pain.

The symptoms are practically indistinguishable from those of the phlebitis which accompanies it.

Recovery may be brought about by the enlargement of collateral channels or by the canalisation of the thrombus and restoration of the original channels, but it is a slow process when a large vessel is involved.

Embolism.—The dislodgment of a thrombus may occur either from mechanical causes, such as sudden movements or undue fingering of the part, or from softening and disintegration of the clot from septic changes in it. In the former case the subsequent symptoms are due to the mechanical interference with the circulation of the part in which the embolus lodges, while in the latter the infective nature of the embolus leads to the formation of widely disseminated foci of suppuration and to a condition of pyæmia. Following the course of the blood stream, the embolus is carried first to the right side of the heart, and thence to the pulmonary artery, where it may be arrested and produce a pulmonary embolism, and such an occurrence is a frequent cause of sudden death. If the clot be smaller, and able to pass through the capillaries, it may pass to any other organ, and as such small emboli are often of a septic character, secondary abscesses are produced in the liver, kidneys, or joints, or in fact in any tissue of the body.

Phlebitis.—*Ætiology.*—Phlebitis may arise in those conditions in which the vein is exposed to injury or irritation directly, as in wounds, burns, etc.; but the phlebitis in such cases is, as a rule, slight, and does not attract special attention. Much more important are those forms in which the phlebitis arises apparently without any external local cause, and is accompanied by thrombosis.

Much discussion has taken place on the question as to whether the thrombosis is the primary condition or is secondary to the phlebitis. It is known by experiment that mere stasis of blood in a vessel, if the vessel is healthy, does not produce coagulation, and it has therefore been supposed that the phlebitis is the primary condition. There is no doubt, however, that the walls of the veins are occasionally diseased, and exhibit appearances similar to those found in atheromatous arteries, with degenerative changes (endophlebitis obliterans), and in such conditions it is possible that there may have been no acute affection of the vessel wall previously. Atheroma may be more frequently present as a cause of phlebitis than is suspected, since thrombosis will more readily occur in a vein that is diseased than in a corresponding artery, as the flow of blood is slower. The phlebitis is, however, usually the primary condition, and is due to a variety of causes, mostly of a constitutional nature, such as gout, anæmia, convalescence from many illnesses, especially influenza and typhoid fever. A varicose condition of the veins always is a predisposing factor in the ætiology.

The inflammation may attack one or other of the coats of a vein, but the walls are so thin that it is impossible to recognise the different forms clinically.

The inflammation may be of a simple plastic kind, or septic in character, the infection in such cases usually affecting the vein from without, and a chronic form of phlebitis occurs, frequently in syphilitic subjects.

Clinical Features.—Phlebitis is specially liable to occur in varicose veins, especially in the dilated veins of the rectum or lower limb. The inflammatory changes are accompanied by the classic signs of pain, redness, heat, and swelling, and the impaired function of the vessel consequent on the thrombosis produces characteristic swelling and œdema in the lower parts of a limb.

The pain may be dull and aching or sharp and shooting in character, and the swollen, red appearance along the line of the vessels is typical when a superficial vein is affected. There is tenderness, and on feeling the part a firm cord can be felt. The œdema is very marked in some forms, especially the gouty, but the free anastomosis between superficial veins may render it only slight. The firm cords present swellings at the position of the valves, but the parts must be examined with great caution.

Clinical Groups.—1. Phlegmasia alba dolens, occurring notably in childbed, but also occurring in convalescence from typhoid fever, is shown by a rise of temperature to about 102° for some days, by severe pain, and by a characteristic œdema of the limb.

2. Anæmic or chlorotic form, forms a clinical entity, though its ætiology is obscure, and is accompanied by the usual phenomena of the disease. Both lower limbs are frequently affected, and there is a rise of temperature lasting about a week, with considerable pain and œdema of the limbs.

3. Gouty phlebitis is a common form, occurring in gouty subjects frequently apart from an acute attack. It frequently affects both limbs, and shows a tendency to shift from one vein to another. There is aching pain and tenderness which lasts for days, and there is considerable œdema of the parts below, the swelling being very tense in character. Such forms are very liable to embolism.

4. During convalescence from certain diseases phlebitis may appear, and the diseases after which it is most liable to occur are typhoid fever, influenza, and pneumonia. After typhoid, phlebitis usually occurs in a mild form, while the post-influenzal form is more acute and severe.

5. In tuberculosis a tubercular form of phlebitis is occasionally seen, caused, apparently, by the deposit of the organism on the vessel wall from the blood stream; and an acute phlebitis may be brought about in the same way in the course of septicæmia.

6. A chronic form of phlebitis not infrequently occurs in individuals affected with syphilis, and is characterised by thickening of the vessels, and by a certain amount of pain and slight tenderness.

Treatment.—In all forms of the disease the patient must be confined to bed, and the limb should be elevated, and it is advisable to immobilise it by the application of a light splint and a bandage, or by lateral sandbags. Heat relieves the pain, and the part should therefore be kept warm. Some local application is advisable, and an unguent, consisting of equal parts of glycerine and extract of belladonna, may be smeared on without friction, and the limb then covered with cotton-wool and a bandage.

The general treatment consists in that applicable to any form of acute inflammation, such as a saline purge and a light diet for cases where the circulation is good. When the thrombosis and phlebitis are consequent upon a general impairment of vitality, a nourishing diet, with tonics and cod-liver oil, is indicated. The rule is to treat constitutionally the general condition, and the frequency of a gouty element being present should not be lost sight of, and such cases treated with colchicum, alkalies, and iodide of potash.

Should the phlebitis show a tendency to spread upwards along the course of a superficial vein and to affect larger vessels, the danger of embolism is increased, and it may be advisable to excise a portion of the vein and thus to interrupt the conducting medium.

Pulmonary Embolism.—Whenever there is recent thrombosis the possibility of part of the clot being detached, carried to the heart, and thence to the lungs, must never be forgotten. Blocking of the smaller branches of the pulmonary artery is often the cause of pulmonary apoplexy, lobular pneumonia, circumscribed abscesses, patches of gangrene, and the like, but it is in the obstruction of the larger divisions that the chief source of danger is found. Complications of this kind occur with a tragic suddenness; for the patient may have been in fair health, suffering only from a slightly painful swelling of some varicose veins in the leg, and suddenly present symptoms of the most severe interference with the circulation and respiration, only gradually recovered from, or terminating in sudden death. When a branch of the pulmonary artery is blocked the circulation is at once cut off from the area of lung supplied by it, since the branches of the pulmonary artery form only capillary anastomoses with one another, and the respiratory function of the part is at once lost.

It has been disputed whether death is due to syncope or to asphyxia, but it is certain that the sudden obstruction of the pulmonary artery causes shock or collapse, and that the patient sometimes dies of this shock within a few seconds.

The symptoms of pulmonic obstruction are by no means typical, and are often indistinguishable from those of angina, or rupture of an aneurysm or of the heart itself, into the pericardial cavity. It must also be borne in mind that many of the recorded cases of sudden death from pulmonary embolism are cases in which the only foundations for the diagnosis were—suddenness of death, possibly from syncope, and the discovery after death of an ordinary fibrinous clot in the right ventricle, prolonged thence into the pulmonary artery and its branches, a clot originating in the spot in which it was found, and the consequence of dying, not the cause of death.

The symptoms of the occurrence of a pulmonary embolism are sudden pain at the heart, with distress and faintness, rapid and irregular action of the heart, and gasping breathing, with distress and lividity. There are not usually distinct physical signs, and the treatment consists in the administration of ammonia in frequent doses, as this substance has the double use of stimulating the circulation, and is said also to have the property of dissolving thrombi.

Suppurative or septic phlebitis, brought about by the invasion of organisms, is often due to infection from some focus outside the vessel, and therefore may occur in any septic wound, or with any suppurative condition, especially when there is tension. It is well typified in the condition sometimes found in the lateral sinus of the cranium and the internal jugular vein in connection with middle ear disease (*q.v.*).

When the thrombus undergoes infective softening the vein wall and the tissues round it become the seat of an intense inflammation, the signs of which are obvious in the case of the superficial veins and in the deep veins, such as the internal jugular; fulness and tenderness along its course may be discovered.

The condition also occurs in connection with septic inflammations in cellular tissue, especially when the tissue is dense, as in the subcutaneous tissue of the face, and consequently there is tension. Such conditions as "facial carbuncle" are liable to produce a septic thrombosis of the branches of the facial vein, and the gravity of the condition is increased by the liability of the infection of the intracranial veins and sinuses by spread of the thrombosis by direct continuity.

The local symptoms are those of an acute phlebitis, with great redness and swelling, and with severe general symptoms of a high fever. The prognosis is very grave, and everything depends upon limiting the spread of the disease. The condition must be treated on surgical lines, by laying open the inflamed vein, removing the infected thrombus, and thoroughly cleansing the cavity and stuffing lightly with iodoform gauze. In advancing cases the vein should be exposed on the cardiac side, tied and divided, and a current of fluid directed along the channel from the opening to the seat of thrombosis, as in lateral sinus thrombosis in middle ear disease (*q.v.*).

VARICOSE VEINS

Varicose veins; Synon.: *Varix, Phlebectasis;* Fr. *Varice;* Ger. *Krampfader.*

The condition indicated by this term is one of permanent over-distension of the walls of veins, with lengthening and tortuosity of the vessels, accompanied by changes in the walls of the veins. Such a condition occurring in the veins of the scrotum is known as a varicocele (*vide* "SCROTUM"), and it is most common in that site at the anus, and in the veins of the lower limb, but it may occur in any set of veins from obstruction to the return circulation.

The condition is only recognisable when the superficial veins are affected, but deep veins may be varicose also, especially in the venæ comites of the veins of the leg.

The ætiology of the condition is not quite clear in all cases, and many causes have been suggested.

Before considering the probable causes that bring about a varicose condition in that commonest region, the lower limb, it is necessary to understand the nature of the pathological changes that occur in the vessels.

Either of the saphena veins may be affected, or both, and the distension may only be noticeable over a small part of the vessel. Frequently one sees a bunch of enlarged veins and the formation of a distinct tumour; in other cases no stem of a single vein is affected, and a long sinuous prominence is seen.

The veins are thickened as well as dilated, and they do not collapse when divided, the thickening is due to an increase of the fibrous tissue in the wall, and the vessel is elongated, as there is a hyperplasia in the long axis as well as in the transverse.

The valves, at first thickened, become incompetent, and may degenerate into fibrous cords.

Large sacculated dilatations may form at the bends of veins, or where a superficial one joins a deep vein. The essential change is apparently an over-distension of the vessel wall, and the wall once over-distended undergoes the fibrous changes which are common to tissues which are over-exerted.

One is often at a loss to discover a reason for the primary over-distension.

Dilatation of the prostatic plexus is common in elderly persons, and of the rectal and anal veins in persons who have congested liver or who suffer from constipation.

A general impediment to the venous return, such as chronic heart or lung disease, causes a general over-distension of the veins, and those of the lower extremity, being the longest and having the weight of the column of blood to bear, will suffer first.

Local obstructions, such as an overloaded colon or an enlarged uterus, will tell on the veins of the lower limb; and muscular strain, such as severe efforts in bicycling or running, may determine varicosity of the veins in healthy young adults.

Occurring in the veins of the upper limb, it is usually due to pressure on the main vessels from a tumour in the axilla or in the superior mediastinum, or to an arterio-venous aneurysm.

The veins of the anterior abdominal wall become highly varicose in cases of obstruction to the inferior vena cava, and a similar condition is found in the veins of the alimentary canal, especially of the stomach, in hepatic cirrhosis.

Occurring in the lower limbs it is frequently due to obstructive causes, such as a loaded rectum, a pregnant or enlarged uterus, the wearing of tight garters, and excessive muscular effort; but all these factors may be present and yet no varicose veins result; the importance to be attached to them is somewhat doubtful.

Certain individuals appear to be more liable, and a tendency of this kind may be inherited; and deficient support of the veins is also a cause, especially in the lower limb, where the weight of a long column of blood has to be supported by the vessel wall, if for any reason the valves be incompetent. The gradual distension of the veins leads to this incompetence, and thus a *circulus vitiosus* of vascular dilatation and valvular incompetence may be set up, and lead to progressive spread of the varix.

The signs and symptoms are quite distinct when the parts are examined, as the enlarged veins stand out in the form of rounded, tense, tortuous cords, often with local areas of dilatation amounting to the formation of a tumour as large as a walnut. The internal saphenous vein and its tributaries are often affected, and a mass of tortuous vessels is found on the inner side of the knee.

Changes are seen in the cutaneous venous radicles, which are injected, and there may be œdema of the lower part of the limb. The skin appears glazed, and as the nutrition of the limb suffers some complications are common.

Cutaneous conditions of the nature of eczema, and a diminished power of resistance to injury or irritation, often lead to ulceration, and there may be rupture of the veins, leading to hæmorrhage, which is always severe and may even be fatal, as the bleeding is aided by the whole weight of the column of blood in the veins between the point of rupture and the main abdominal vessels. The patient complains of tired aching feeling, or even of acute pain, of frequent cramps, and is disabled from prolonged walking exercise. The pains may be mistaken for rheumatic conditions unless an inspection of the limb be made. The examination of the part is to be completed by getting the patient to lie down with the limb elevated till the distension has subsided; and then putting the thumb upon the termination of the internal saphenous vein and pressing firmly upon it, the patient is asked to stand up. The pressure on the vein removes the weight of the column of blood in the upper vessels, and as it usually renders the venous distension to be only slight, we can judge of the effect likely to be produced by ligature or removal of this part of the vein.

Treatment.—1. *Palliative.* 2. *Radical.*—Palliative treatment consists in the use of some appliance which gives artificial support to the veins, and it is often found to give great relief to the symptoms, and to lead to improvement. The support may be a well-fitting elastic or silk stocking or a bandage, applied to the limb from below upwards.

A domette or cheese-cloth bandage, or one of elastic webbing, applied by the figure-of-eight, or "Watson's" method, is the most suitable, and it should not be applied very firmly, as subsequent swelling of the limb may cause injurious constriction. The patient should sleep with the lower end of the bed raised, and apply the stocking or bandage before getting out of bed, and not remove it until after he has gone back to bed.

Massage removes the tired aching feeling, and improves the nutrition of the limb, and in addition a moderate amount of walking exercise is advisable.

Intercurrent attacks of phlebitis are fairly common, and may lead to a cure from the accompanying thrombosis, and these attacks are to be treated on the lines previously indicated.

The radical treatment is to be advised when there is much pain, when the palliative treatment cannot be carried out, when there is a tendency to the occurrence of complications, if the patient is otherwise suitable for operation, and in candidates for the physical examination for His Majesty's services.

The cases most suitable for operative treatment and in which a good prospect of cure may be entertained are those in which the varicosity is confined to one vein, or where the condition is definitely localised.

In the former class the internal saphenous vein, for instance, may be the main vessel affected, and it may show an over-distension in one or two parts of its course.

In the latter there may be a definite and localised dilatation of both saphenous veins, but those cases where there is a diffuse enlargement of both veins and of their tributaries do not afford such suitable conditions for operation. The more the varices lie longitudinally, *i.e.* in the line of the trunk, the better and more lasting is the result.

The operation for varicocele is successful because the whole affected mass can be isolated, and the same condition in the lower limb, similarly treated, gives equally good results.

Many different forms of operative interference have been recommended.

The earlier ones depended for their success upon producing a localised thrombosis of the vessels, and this was attained by the injection of irritating or astringent fluids, but as this was by no means free from risk, it has been abandoned. Other methods consist in removing skin, so as to tighten up the cutaneous covering of the limb and provide an artificial support like a stocking.

It is of the greatest importance to be sure of asepsis in undertaking any operation on the veins.

The usual and best form of operation is that which consists in taking out the affected vein by a long incision and dissection, or by removing an inch or two at intervals, by separate incisions, and by treating the terminal part of the internal saphenous vein in the same way when its tributaries are affected.

The affected veins should be marked out in the skin before operation with carbol fuchsin, as it may be difficult to find the vessels when the patient is recumbent.

Longitudinal incisions are made over the varices, and about 3 inches of the vessel removed.

A modification of the operation consists in exposing the vein by a short incision, freeing it for a short distance, and then with forceps seizing the vein and twisting it, so drawing out a considerable length and at the same time arresting the bleeding.

Careful ligature of the tributaries is important to prevent subsequent hæmorrhage.

The incisions are carefully sewn and a dressing applied, and the limb should be bandaged over the whole length and put in a splint. The patient may be kept in bed for three weeks, and should be instructed to avoid muscular overstrain, and, if necessary, to wear an elastic or silk stocking for a short time longer.

It is often necessary to excise a varicose vein above an ulcer in order to get healing of the ulcer. This may be done although the other indications for operative interference are absent.

Other diseases of veins, including the presence of the embryos of tænia and the bilharzia hæmatobia, and the occurrence of some functional conditions, of which a spasmodic contraction of the veins of the lower limb is the best recognised, require only to be mentioned. The latter condition resembles a thickening of the wall of an organic nature, but is distinguished by being removed by the application of heat.

Entrance of Air into Veins

The explanation of this occurrence is found in one of the factors already mentioned as bringing about the venous flow, namely, the aspirating effect of the heart and of respiratory movements. The thoracic cavity being a closed chamber, increase of the size results in the aspiration into it of air, or of blood into the great veins leading to the heart, and therefore at every respiratory movement the thorax acts as a pumping mechanism, drawing in and expelling blood as well as air. This effect is propagated along the great veins of the neck.

To resist this tendency, we find that the veins of the neck are, as a rule, surrounded by strong fibrous sheaths attached to adjacent structures, so that the vein does not collapse, as it would do were the wall not supported, and an arrangement of this kind is found even so far from the heart as in the axillary vein.

In pathological conditions, further, a vein may be embedded in dense fibrous tissue, may be adherent to adjacent structures, or the wall may be infiltrated and rendered firm.

Lastly, undue traction upon tissues during the course of a surgical operation may prevent a vein collapsing.

In any of these conditions, should the wall of the vein be opened air is aspirated into the vein. The accident is especially liable to happen if a small piece has been cut out of a vein, *e.g.* in removing an adherent gland, or if the wall is only partially divided.

Practically, the accident is most liable to happen during the course of operations about the root of the neck or the axilla, when the tissues are matted from chronic inflammation or from tumour growth, and when a slight wound is made in the side of a large vein, or if a tributary vein be divided close to its termination in the main vessel.

The accident has occurred, however, even in the facial, subscapular, femoral, and uterine veins.

The signs and symptoms are a gentle hissing or sucking sound, intermittent in character, and the presence of some frothy blood in the wound, together with an immediate and serious interference with the patient's circulation and respiration, evidenced by sudden pallor, deep and sighing respiration, and rapid flickering pulse, with violent and turbulent cardiac movements. These effects are due to two causes: first, the cardiac muscle is deprived of its usual stimulus, viz. an incompressible fluid, in place of which it has only a mixture of air and fluid in which to act; and, secondly, to impairment of the natural action of the cardiac valves, which are only suited to act in a fluid medium, and are useless in air or froth. The pulmonary circulation is arrested, and the patient may die rapidly and suddenly, or may gradually recover, if the quantity of air that has entered is only small.

Treatment.—The treatment must be immediate, and, first of all, the entrance of further air be prevented, either by pressure with the finger or swab upon the aperture, or by flooding the wound with some non-irritating and non-poisonous fluid, such as warm saline solution. It is doubtful if anything can be done to get rid of the air in the heart, but violent expiratory movements sometimes eject it, and the expiratory movements may be assisted once very rapidly. To prevent cerebral syncope the head should be lowered, and the main arteries of the limbs compressed, or even the abdominal aorta, so as to divert the arterial blood to the brain as much as possible. At the same time stimulants should be administered, such as ether subcutaneously, brandy by the rectum, hot cloths to the præcordia.

It has been suggested to aspirate the right auricle by a hollow needle and an aspirating syringe, but this is a *dernier ressort* of a desperate character.

Venereal Disease.

See "YAWS."

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VENEREAL DISEASES IN ANIMALS—
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THE term "Venereal Disease" is applied to certain affections due to the inoculation of different varieties of micro-organisms, which often occurs in those who are addicted to promiscuous sexual intercourse. But venereal disease is in every way a bad expression. It has neither a pathological nor a clinical significance, for it groups together a number of wholly different conditions which are not even causally connected, since each of the component affections can only be produced by inoculation with the appropriate culture. The diseases included in the general heading venereal disease, are—gonorrhœa, syphilis, soft sores, venereal warts, and certain affections such as yaws and radesyge, which a better knowledge of pathology has now relegated to their appropriate place. Gonorrhœa (vol. iv. p. 191), the urethritis caused by gonorrhœa (vol. xiii. p. 57), and syphilis (vol. xii. p. 1) have already been described sufficiently, and the following article deals chiefly with soft sores and venereal warts.

History.—Much useless but ingenious speculation has been devoted to the history of venereal disease, but the hyperbole of Oriental languages, the vague descriptions of classical satirists, and the reticence of the early physicians and surgeons, do not allow of any accurate statements. It appears, however, that syphilis is a new disease so far as the Old World is concerned, that gonorrhœa was less troublesome in classical times than it is now, and that soft sores and venereal warts have long been recognised as a consequence of impure intercourse between the sexes.

Soft Sores or Chancroids are ulcers produced by the inoculation of a particular form of micro-organism known as Ducrey's bacillus. The organism is short and thick, with rounded ends, looking much like a figure of eight. It is found in the cells as well as in the intercellular spaces of the affected parts, and its presence has been demonstrated in some of the buboes which are so often associated with soft sores. The strepto-bacillus can be cultivated on a medium consisting of two parts agar and one part of blood from the human subject, the dog, or the rabbit, and it is stained by alcoholic solutions of fuchsin, methyl-violet, and gentian violet. A successful inoculation with this micro-organism alone will produce all the characters of chancroid, but the course of the chancroidal ulcer contracted in the usual manner is modified by the presence of other pyogenic and pathogenic organisms, of which the staphylococci and streptococci are the most important.

Course.—Soft sores and the initial manifestation of syphilis or the hard sore are often mistaken for each other, owing to the fact that a person who contracts syphilis may also be infected with the poison of a soft sore. A chancroid, however, has only a short incubation period, whilst the hard sore does not show itself for many days after inoculation.

The first manifestation of a soft sore occurs within a few hours of inoculation, and is very rarely delayed more than a week. A vesicle appears at the seat of inoculation, and rapidly becomes pustular, forming a rounded ulcer which soon becomes inflamed, though its base never attains to the induration of the hard sore, which is the first manifestation of syphilis. The walls of the ulcer are undermined, its floor is irregular and covered with a yellow exudation. The ulcer secretes pus in abundance, and the pus is infective, for it is capable of inoculation upon the same individual as well as upon other people. Soft sores, therefore, are often multiple, whilst it is quite unusual for a syphilitic sore to be other than single (see vol. xii. p. 7).

Differential Diagnosis.—Soft sores are found on the genital organs, as they are usually contracted during sexual intercourse. They occur in men on the glans penis and on the prepuce near the frænum; in women, at the fourchette and on the inner surface of the labia, as well as near the anus. Soft sores have to be distinguished from the initial manifestation of syphilis, from herpes, from balanitis, from gummatous ulceration, and from tuberculous ulceration. They can be distinguished from syphilis by their number, by their capability of inoculation, by the shorter incubation period, and by the smaller amount of induration. Yet these differences only hold good for typical cases, and may each and all fail in the very cases where it is of the greatest importance to distinguish between soft and hard sores, for the simple reason that a person who has contracted a chancroid may at the same time have become inoculated with syphilis. It is unwise, therefore, to make the diagnosis too absolute until lapse of time has rendered it quite certain that the patient has not got syphilis.

Herpes progenitalis, or præputialis, when it occurs in men, is very likely to be mistaken for soft sores if the vesicles have become inoculated with pyogenic organisms. The condition of herpes occurs both in men and women: the eruption is vesicular at first, and is often unilateral or in accordance with the nerve distribution. Dr. R. W. Taylor lays particular stress upon the fact that chancrous erosions assume a round or oval outline, while herpes has a polycyclic form with festooned margins, due to the fusion of groups of vesicles, a polycyclic outline being that which is presented by two pieces of three-leaf clover placed base to base. Bacteriological examination of the secretion from the inflamed surface will assist the diagnosis in difficult cases; but as a rule the sensations of heat, itching, and burning, the superficial character of the lesion, its less profuse secretion, the scarcely undermined edges, and the tendency to relapse, will distinguish the eruption of herpes from soft sores.

Balanitis is an inflammation of the mucous membrane of the prepuce, or glans penis. It is often associated with soft sores, though it may occur quite independently. The diagnosis can often only be made after the prepuce has been incised, and the soft sores are laid open to view.

Gummatous ulceration is to be distinguished from soft sores partly by the slower course which it runs, partly by the history, and partly by the difference in the glandular enlargement, for in soft sores buboes are formed, whilst in gummatous ulceration there is less tendency for the glands to suppurate.

Tuberculous ulceration of the penis or vulva can only be distinguished from soft sores by a thorough bacteriological examination, which should include more than one inoculation of the suspected tissue. The patient often shows other signs of active tuberculosis, and the tuberculous inflammation runs a slower course than that due to chancroids.

Complications.—Buboes, phimosis, paraphimosis, gangrene, sloughing, and phagedæna are the more important complications attending the inoculation of chancroidal pus.

Buboes are enlargements of the superficial inguinal glands, which lie horizontally along Poupart's ligament; the more numerous glands grouped vertically over the upper part of the internal saphenous vein are not so often affected. The inflammation varies from a slight lymphadenitis, which shows no tendency to suppurate, to a virulent inflammation which spreads with alarming rapidity, and may cause ulceration of the femoral vessels. Buboes are seen more frequently in hospital than in private practice, so that carelessness and want of rest are predisposing factors. The nature of the infection, too, bears some relation to buboes, for the worst forms are not necessarily associated with the most angry sores. The bacteriology has not yet been worked out fully, but the specific strepto-bacillus has been found in the abscess wall of the glands, as well as in glands which have not yet suppurated. Some buboes, on the other hand, have been found to be free from Ducrey's bacillus though they were due to soft sores.

The symptoms of a bubo are those of an ordinary infective lymphadenitis. A tender swelling, which at first is movable, occupies the position of a lymphatic gland. The swelling soon becomes fixed, and the overlying skin shows signs of inflammation.

Treatment.—Rest in bed, with the application of fomentations of boric acid (20 grains to the ounce), will often allay the glandular inflammation if it be seen early, especially if this treatment be supplemented with a calomel purge, followed by a course of quinine and iron. In three cases, when the soft sores had been cured and the glands were on the point of suppuration, whilst the patient was unusually anxious to avoid the inconvenience of a prolonged healing, I have consented to dissect out the affected glands by a formal operation. The end justified the means in every case, for healing took place by first intention, and the patient has been repaid for his fortnight in bed. Such cases, however, must be chosen with care, and is useless if the chancroid is uncured. The more usual treatment consists in carrying an incision into the suppurating gland parallel with the femoral vessels, *i.e.* at right angles to Poupart's ligament. The pus is allowed to escape, and the remains of the gland should then be scraped away with a sharp spoon, the cavity being swabbed out with a solution of chloride of zinc (40 grains to the ounce), and afterwards irrigated with a saturated solution of boric acid at a temperature of 110° F. The cavity is then lightly plugged with iodoform gauze, and is allowed to heal from the bottom. It is often advisable to order a patient to take prolonged warm baths in cases where there is extensive destruction of the skin in connection with the buboes, and it may be necessary to employ various escharotics to arrest the ulcerative process when it is found to be spreading rapidly. It should be borne in mind, however, that the rapid extension of the ulceration is due to the multiplication of micro-organisms in a favourable medium, amd that no escharotic acts far from its point of application. The general condition of the patient, therefore, must be improved, and the diseased tissue should be thoroughly scraped away before the nitric acid, formalin, carbolic acid, or nitrate of silver is applied.

The abortive treatment of buboes by the injection of iodoform emulsion or carbolic acid at a comparatively early period has not proved satisfactory in my hands as a general rule, and in the successful cases I have thought that the result was rather due to the rest in bed than to the antiseptic injected.

Phimosis and Paraphimosis.—Phimosis is one of the commonest complications of soft sores in men who are careless, or who have been treated too actively. It is due to an inflammatory swelling of the prepuce with an accumulation of pus beneath it. The inflammatory process runs a rapid course, and may end in such perforation of the prepuce as to cause exposure of the glans or even ulceration of the urethra.

Paraphimosis is a rarer complication of soft sores, and is due either to the swelling of a short foreskin or to the forcible retraction of an unduly long one. The swelling of the glans penis is greatly increased, and great œdema occurs owing to the inflammation of the soft sores.

Treatment.—A patient with commencing phimosis must, if possible, be kept in bed with his penis enveloped in a compress of lead lotion and slung against his abdomen. He should further be ordered a calomel purge, and he should be placed upon a course of quinine. If the inflammation continues in spite of this treatment the prepuce must be slit up, for in no other way can the inflammation be arrested so satisfactorily. The parts should be rendered as aseptic as possible, and the patient is placed under the influence of nitrous oxide gas or of somnoform, though many prefer the use of cocaine or eucaine. A director is introduced through the orifice of the prepuce, taking care that it does not pass into the urethra, and is carried onwards to the corona. A curved bistoury is passed along the groove, and is made to transfix the prepuce at the level of the corona, and the incision is carried through the whole thickness of the prepuce to its free edge. The cut is generally made along the dorsum, but Dr. Robert A.

Taylor has lately expressed his belief that better results are obtained by employing two lateral incisions. The prepuce is then converted into an upper and a lower flap, and the glans is much more freely exposed than by the old method. The bleeding is not serious in either case, and is readily arrested by the application of a dry dressing of tannoform or iodoform gauze kept in place by a couple of turns of rubber plaster.

Paraphimosis is more amenable to treatment than phimosis. Rest in bed with the application of a compress of lead lotion will usually allay the inflammation sufficiently in a few hours to allow the prepuce to be replaced over the glans, and it is only in the rarest cases that it is necessary to divide the constriction. Reduction is effected in the usual manner by first squeezing as much blood as possible out of the glans either by digital or elastic pressure, and then pulling the foreskin over it.

Gangrene and sloughing phagedœna affect the penis, the groin, or the skin over the pubes by an infection which extends rapidly in persons who have a diminished power of resistance either from acquired or constitutional causes. The tuberculous and diabetic are said to be more likely to suffer from phagedæna if they contract soft sores than are healthy persons. It is certain that habitual drunkards are more liable to this form of inflammation; but phagedæna is much less commonly seen since the introduction of antiseptic treatment, and since the administration of mercury has been restricted to those who have syphilis.

Treatment.—The treatment consists in placing the patient under an anæsthetic, scraping away all the diseased tissue with a sharp spoon, brushing the wound with nitric acid, paying special attention to the edges, which must be thoroughly destroyed, and afterwards packing the whole surface with dry iodoform gauze which has been sterilised. The patient ought to be well fed, he should be given a liberal allowance of alcohol, and a grain or two of opium in the course of every twenty-four hours will often prove to be of the greatest benefit.

The most severe cases of sloughing phagedæna can sometimes be cured by almost continual immersion in a warm bath. Fortunately, such cases only occur in hospitals, for it is only in a public institution that this course of treatment can be carried out satisfactorily.

The patient can easily be kept in the bath continuously for days or weeks, and if a horse-shoe air cushion be tied round his neck he can sleep securely without danger of being immersed. The water must be changed and the bath thoroughly cleaned once every twenty-four hours. The patient should be wrapped in blankets and laid on a bed whilst this is being done, and it is convenient that he should have an action of the bowels at this time. It is quite possible, however, to employ a bed-pan in the bath with very little soiling of the water. The bath may be so arranged as to allow of a constant flow of water through it, or, if it be medicated (vol. i. p. 435), some of the water may be drawn off and fresh water may be added every hour and a half. The temperature of the water is maintained at 99° to 100° F.

The base of a soft sore is sometimes covered with a greenish or yellow membrane, and the ulcer is then called *diphtheritic*. Such ulcers run a somewhat chronic course, though they can be easily stimulated into activity and heal readily.

Considerable tracts of skin occasionally become involved in chronic ulceration as a result of infection with chancroidal virus. The edges of the advancing ulceration are curvilinear—whence the name *serpiginous*—whilst the seat of inoculation cicatrises. Serpiginous ulceration in this country is often associated with previous syphilitic infection, and always occurs in unhealthy people. It is treated constitutionally, as if the patient had tertiary syphilis; locally, by thoroughly scraping and disinfecting the surface and edges of the ulcer. An analogous condition, which is certainly not syphilitic, is known as ulcerating granuloma of the pudenda (see p. 311).

Allied Diseases.—Certain affections have always been branded as venereal, though in many instances pathology has relegated them to very different classes, and has shown that they are not necessarily contracted during sexual intercourse.

Venereal warts are perhaps the best known of these allied affections. They are papillomata found about the genital organs. They grow at the coronary sulcus, at the inner surface and margin of the foreskin, near the frænum and at the meatus in men, whilst in women the labia, the urethra, and the margins of the anus are the commonest seats of growth. They may arise *de novo* from various causes of local irritation, and their growth is favoured by heat and moisture. They occur in two varieties, the hard and the soft warts. Hard warts are often small in size, bright red in colour, round or pointed in shape; soft warts vary in size from minute points to enormous cauliflower-like masses. Both hard and soft warts are usually multiple. They are convertible one into the other, and both, unless they are kept clean, may produce a very foul discharge. Such warts grow rapidly in pregnant women and dwindle again after delivery. There is reason to suppose that venereal warts are contagious in some cases, but it is necessary for the recipient of the infection to supply a proper soil, as it is not every skin or mucous membrane that will grow warts.

Treatment.—The following applications have often given me good results in the slighter forms of venereal warts:—(1) ℞ Pulv. cupri. sulphatis, pulv. foliorum sabinæ, amyli, āā, partes æquales. Fiat pulvis. Signa. Dust the powder over the warts on four successive evenings, and wash away the secretion with soap and warm water twice a day. (2) ℞ Tannin, camphoræ, pulv. foliorum sabinæ, āā ʒss., pulv. zinci oxidi ℥vj. Fiat pulvis. Signa. To be dusted over the warts night and morning for fourteen days.

It is often necessary to remove the growths by operative measures, and it should be remembered that mere ligature and snipping the warts off is insufficient. The surface from which they grow should first be painted with a 10 per cent solution of hydrochlorate of cocaine, and it should then be scraped thoroughly with a sharp spoon, a dry dressing of iodoform or cyanide gauze being afterwards applied. The bases of the large cauliflower excrescences must be dissected out whilst the patient is under a general anæsthetic, the wound being sutured in the usual manner. Cleanliness, in every case, is a great feature in the treatment of warts, and all irritating discharges over the skin or mucous membrane upon which they grow should be stopped as quickly as possible. The persistence of warts in old people will naturally raise a suspicion of epithelioma.

Frambœsia—known in its different localities as yaws, parangi, patéh, pian, buba, Tonga, verruga, coko, purru, and Amboyna button—is one of the best known affections allied to venereal disease. It is endemic in many tropical countries, all its names appearing to have their origin in some African dialect. (See "Yaws.")

Radesyge is known in Norway as spedalsked. It was long described as a form of syphilis, but it is now classed with leprosy. It occurs on the seacoast of Norway, Sweden, Iceland, and Greenland, and is characterised by an ulceration of the nose, mouth, and fauces, which superficially resembles the ulceration of syphilis. Cleanliness, good food, and warm clothing form the prophylactic treatment. Sarsaparilla with small doses of mercury may be given with advantage, and the sores should be dressed with boric fomentations.

Sibbens was endemic for a long time in the south of Scotland, though it seems now to be extinct. It attacked infants, who transmitted it to their nurses. The eruption was a fungating, copper-coloured growth, associated with ulceration of the palate and an aphthous ulceration of the mucous membrane of the mouth. The eruption on the skin was widely distributed and usually scabbed. Alibert described the disease as a syphilitic mycosis, but it is probable that its true pathology will never be known.

Scherlievo, or the mal de Fiume, appears to have been syphilis occurring amongst an unprotected and poverty-stricken population. It derives its name from the small village on the shores of the Adriatic where it was noticed to be epidemic in June 1800. The first symptoms were pains in the bones, especially at night, the pains were followed in a fortnight or three weeks by dysphagia and hoarseness, with the appearance of rounded ulcers on the velum palati and on the inner sides of the cheeks and lips. Large coppered-coloured spots appeared upon various parts of the body, which underwent deep and extensive ulceration. The disease was contagious and one attack protected. Mercury was curative when administered internally.

Falcadina presents many points of resemblance to scherlievo. It was first observed at Facaldo, a village in the Austrian Tyrol, about 1786. It became epidemic, and was propagated by sexual intercourse. The disease was characterised by ulcerating pustules with blennorrhagia, condylomata, and buboes, whilst the bone showed nodes. The mortality was great at first, but afterwards the epidemic died away.

Morula or *button scurvy* appears to have been allied to syphilis. It occurred in Ireland during the early part of the last century, but is now extinct, and as the pathology of venereal disease was at that time in a state of extreme confusion, it is unlikely that the exact nature of the disease will ever be known. It has, therefore, to be classed with Saint Euphemia's evil (1727), the disease of St. Paul's Bay (1760), of Brunn in Moravia, and of Chavanne Lure, as probably syphilitic in origin.

Ulcerating granuloma of the pudenda is also known as "The Groin Ulceration" of British Guiana. It begins in the form of papules which increase in size, become abraded and then granulate. There is not much suppuration, but the abraded surfaces bleed readily and finally scar over. (See also "PUDENDA," vol. x. p. 127).

VENEREAL DISEASE IN ANIMALS.—Horses and dogs are both liable to contract disease during sexual intercourse. "La Dourine," badly called veterinary syphilis, is a disease communicable by coitus, which has long prevailed amongst the horses of the French army. It was first noticed in France at Tarbes in 1851, though it was observed and described by J. Ammon in the grand-duchy of Posen as early as 1796. The disease attacks the reproductive organs, where it presents certain local manifestations, followed by numerous eruptions and by constitutional symptoms, the most prominent being a paralysis of the animal's hind quarters. The duration of the affection is a few months to a year. Death occurs from exhaustion or hypostatic pneumonia, though recovery sometimes occurs.

Dogs suffer from certain infective granulomata often called papillomata, condylomata, and warts. The contagion is conveyed during the act of coitus, and the tumours are not dependent upon the irritation of any discharge.

The tumours can be transplanted artificially. Secondary deposits occur in the lymphatic glands, as well as in the liver and spleen, but the growths can only be inoculated upon dogs. Much further investigation is required in connection with the pathology of these interesting growths, for it is said that they may be inherited, and it is possible that the tumour cells are themselves infective.

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Venesection.

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THIS operation consists in the abstraction of blood by incision into a vein. The median cephalic vein at the bend of the elbow is the vessel usually selected. The operation is done as follows: The skin of the part is thoroughly cleansed, and a bandage is then rolled tightly round the upper arm, and the patient is directed to grasp something firmly in the corresponding hand. The skin over the vein is then gently stretched by the fingers of one hand of the operator, and an *oblique* incision is made across the vessel with a sharp sterilised knife. The blood is allowed to flow into a vessel until a sufficient quantity has been withdrawn. This operation was formerly very much used, and in a somewhat indiscriminate manner, for all sorts of diseases, acute or chronic, whether in sthenic or in asthenic individuals. It is now comparatively rarely used, but there are good reasons for believing that it is a valuable therapeutic measure, and that its judicious use at the present day would be beneficial.

There are two types of disease for which it is specially applicable: (*a*) in advanced cases of heart disease, when the heart is dilated, its muscle weak, the peripheral circulation distended, and the orthopnœa and general distress of the patient are extreme, the abstraction of from 4 to 10 ounces of blood is sometimes followed by the most striking relief, this occurring in cases where the usual cardiac remedies have been tried with little or no result. Even although the relief in such cases may not be permanent, the favourable results of the operation warrant its adoption in some cases. It should only be carried out after the more ordinary modes of depletion have been tried, *e.g.* judicious use of cathartics and diuretics, combined with the administration of general and local cardiac tonics. Before considering venesection in such cases care should be taken to see that the aggravated nature of the symptoms are not in great part due to the presence of hydrothorax, the relief of which by aspiration may be followed by very satisfactory results.

(*b*) In cases of acute pneumonic fever, especially in sthenic subjects, venesection may be beneficial in some cases. Its manner of action is probably a twofold one. It directly relieves the strain on the cardiac muscle, and is indirectly beneficial, through the removal of a quantity of the toxic material that is present in the blood in these conditions, and which is responsible for the symptoms of the disease.

Interesting sidelights on the value of venesection are sometimes afforded in other departments of medicine. Thus in obstetric practice it is occasionally observed that in acute infection occurring after pregnancy or in the puerperium, *e.g.* eclampsia or puerperal septicæmia, the occurrence of a free uterine hæmorrhage is followed by a very marked improvement in the symptoms, and in some cases has apparently been the means of saving the patient's life. The manner of action in such cases is probably identical with that already described.

In cases where venesection is indicated the use of transfusion of saline fluids (see "TRANSFUSION"), or the subcutaneous or rectal injection of neutral salines, may be a very useful adjunct to treatment.

Venomous Animals. *See* SNAKE BITES, etc., vol. xi.

Ventilation and Warming.

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1. THE PROBLEM.—The problems associated under the term Ventilation arise out of the relation of the lung-breathing organisms to their environment. For simplicity, these problems may be studied on the human organism, but all the higher mammals, in their degrees, require similar conditions. If a human being always lived in the "open air," there would be no problem of ventilation; for the organism would absorb from the air precisely the amount of oxygen necessary for perfect respiration, and discharge into the air a certain amount of carbonic acid, aqueous vapour, and the other metabolic impurities that issue normally by the lungs. If the air became disagreeable, or unwholesome, as from offensive gases, from marshes, or fires, or volcanoes, or factories, or decomposing organic materials of any sort, the ventilation problem could be solved by walking away; but where the open air of a region becomes too impure for respiration, ventilation in the ordinary sense is not a remedy. The real problem of ventilation arises from the fact that to live at all in a variable climate the human organism requires shelter; the shelter, being necessarily limited, rapidly accumulates impurities, and as these would, in concentration, become fatal, they must either be reduced to an amount compatible with physiological living, or, if possible, be altogether eliminated. The central problem of ventilation, therefore, is how to maintain, within a partially closed space occupied by a human being, the same quality of atmosphere as may be obtained in an open healthy locality.

2. The chief factors in the solution of this problem are the following:—

First, the composition of average, unpolluted air.

Second, organismal pollutions—respiration.

Third, environmental pollutions—combustion of coal, coal-gas, paraffin or other oils, candles, or other substances used for lighting or heating; pollution from floors, drains, walls, domestic industries, as cooking, washing, etc.

Fourth, the physiological standard of air-purity.

Fifth, the dynamics of ventilation, and ventilation systems.

The relation of ventilation to warming will emerge in the exposition of these five topics, which form a related sequence. Some further notes on warming will be appended.

3. *First, the Composition of Air.*—The composition of average country air free from aqueous vapour is, according to Haldane, as follows:—

Oxygen	By volume,		20·94
Nitrogen	,,	,,	78·09
Argon, with traces of metargon, xenon, crypton, neon, helium, and hydrogen	,,	,,	0·94
Carbonic acid	,,	,,	0·03
Total . . .			100·00

Normally, air contains aqueous vapour in amounts depending on temperature and pressure, traces of ammonia, traces of sodium salts and other mineral substances, organic matter, particulate or gaseous, micro-organisms, including moulds and bacteria, dust of various degrees of fineness.

For ventilation, the ingredients of primary importance are the oxygen, the nitrogen, the carbonic acid, the aqueous vapour, and the organic matter, living and dead. The others may be neglected.

Oxygen.—This gas is indispensable to metabolism. On the slight variations in the amount of oxygen depends mainly the wholesomeness or unwholesomeness of the air in a locality. Dr. Angus Smith found that it varies from 20·999 per cent (by volume) on an open heath in Scotland to 20·980 in an open space in London in summer; 20·650 in the Court of Queen's Bench, 2nd February 1866, and 18·270 in a badly-ventilated mine. If, however, abundance of air be available for ventilation, the exact percentage of oxygen is not very material; but when the percentage is high, ventilation is easier, and certainly localities where there is a very high percentage are healthier.

Nitrogen.—For respiration, nitrogen is inert; but it forms a diluting vehicle for the oxygen, which, if breathed in concentration, produces symptoms of excitement.

Carbon Dioxide, or *Carbonic Acid.*—For ventilation, this is always an impurity; but in the small percentages present in average air, it is harmless. In normal air, it varies from less than 3 to more than 6 parts per 10,000 volumes. Haldane states that the results by Pettenkofer's method are usually too high by about 0·5 parts per 10,000 volumes of air. In open country, Haldane has found that CO_2 varies from 3·5 volumes by night in summer per 10,000 volumes of air to 2·6 volumes by day in the lower strata in consequence of the influence of vegetation. In dry air the amount of CO_2 in the open country in Scotland is almost exactly 3·0 parts per 10,000 volumes. This result Haldane gives as the average of a series of exact determinations. In 29 analyses made between 1st April and 30th September, he found a day maximum of 3·11 parts per 10,000 volumes, a day minimum of 2·58—average, 2·88. In 23 analyses, he found a night maximum of 3·55, a night minimum of 2·82—average, 3·08. Average of night and day analyses, 2·98. In 6 analyses made between December and January, he found a day maximum of 3·12, a day minimum of 2·93—average, 2·99. In 5 analyses, he found a night maximum of 3·06, a night minimum of 2·94—average, 3·01. Average of night and day, 3·00. In London air the CO_2 varies from 4·5 in clear air to 14·1 in a fog. Analyses made by Dr. Russell during 1882-83 gave an average of 4·01. Probably a more correct average is 3·7. Fogs should be avoided at the time of estimation.

Organic Matter.—This includes micro-organisms, organic dust, organic effluvia of unascertained composition, organic gases. The amount depends on local conditions and on respiration. The hypothesis that the deleterious effect of air from an overcrowded room is due to a particular poisonous organic substance is not borne out by recent analysis (Haldane).

Aqueous Vapour.—For ventilation and warming, aqueous vapour is not unimportant. A very moist atmosphere favours dampness of walls, with consequent chilling; a very dry atmosphere, especially if warmed, causes discomfort. This is probably due to the absorption of moisture from skin and mucous surfaces. Dry air, also, by increasing the rate of evaporation, chills damp objects in a room. To prevent discomfort when air is artificially warmed, the "humidity should not be less than 60 per cent of saturation" (Shaw). Saturation depends, not on the absolute amount of aqueous vapour in the given quantity of air, but on the temperature of the air. Thus 1·1 grain of aqueous vapour saturates a cubic foot of air at 10° Fahr.; but at 50° Fahr. it takes 4·2 grains to saturate the same quantity of air; at 60° Fahr., 5·8 grains; at 80° Fahr., 10·7 grains; at 100° Fahr., 19·1 grains; at 130° Fahr., 42·5 grains. In all these cases the percentage of humidity is 100, which means saturation. It follows that if, for example, air at 60° Fahr. contains only 2·9 grains of aqueous vapour per cubic foot—that is half its saturation quantity at that temperature—it is less humid than air at 10° Fahr. when this contains in each cubic foot only 1·1 grain, which at that temperature is saturation. The amount of aqueous vapour in the air, either in rooms or in the open, can be estimated very precisely by various hygrometers, *e.g.* the wet and dry bulb thermometers.

The humidity of the air conditions, to a large extent, the variations and effects of temperature. A moist air secures greater uniformity of climate. In Britain, owing to the greater humidity, lower temperatures in warming of houses can be tolerated than in America, which is relatively dry. Billings states that in America, to secure comfort, rooms must be kept at a temperature of 68° Fahr. to 70° Fahr.; in England, comfort is secured at 60° Fahr. The amount of aqueous vapour in inhabited rooms varies more or less as the amount of respiratory impurity, and this fact has been made the basis of a method for estimating the impurity. But as a rule, the amount of aqueous vapour varies so rapidly from hour to hour that, except in great excess of impurity, the relation of impurity to vapour is too inconstant to be a reliable index.

Second, Organismal Pollutions—Respiration.—In parts per cent, the difference between inspired and expired air is, according to Foster, as follows:—

	Oxygen.	Nitrogen.	Carbonic Acid.
Inspired air contains	20·94	79·15	·03 to ·04
Expired air contains	16·033	79·581	4·38

The quantities for inspired air differ slightly from the latest averages, but are sufficiently accurate.

Thus the expired air contains from 4 to 5 per cent less of oxygen and some 4 per cent more of carbonic acid. At the rate of 25 cubic inches (tidal air) each respiration and 17 respirations a minute, a man will, in an hour, pollute 102,000 cubic inches to the extent of 1 per cent (volume) of CO_2, which means an excretion of 0·6 cubic foot CO_2 per hour. This quantity approximates to the theoretically expected result of food-metabolism, and has been verified by experiment. But average air contains ·03 to ·04 CO_2 per 100, or 0·3 to 0·4 per 1000 volumes. Consequently, if a man breathes for an hour in a room of 1000 cubic feet (10 ft. × 10 ft. × 10 ft.), the amount of CO_2 at the end of the hour, if no air is admitted or withdrawn meanwhile, will be $0{\cdot}6 + 0{\cdot}4 = 1{\cdot}0$ cubic foot. But air containing this amount of CO_2 due to respiration is unwholesome, and must be diluted until the total CO_2 does not exceed 0·6 parts per 1000. This is done by the admission of 2000 cubic feet of normal air per hour. The man thus is provided with 1000 + 2000, or 3000 cubic feet of air per hour. The amount of CO_2 in cubic feet will then be as under:—

$$\begin{array}{ccccc} (0{\cdot}4 \times 3) & + & (0{\cdot}6) & & \\ \parallel & & \parallel & = & \text{1·8 parts in 3000 cubic feet,} \\ \text{Normal } CO_2 & & CO_2 \text{ contributed} & & \text{or 0·6 in 1000 cubic feet.} \\ \text{in air per 1000 vols.} & & \text{by respiration.} & & \end{array}$$

This standard,—0·6 per 1000—is aimed at in dwelling-houses, etc., but in practice it is rarely attainable. Nor, except in prisons, hospitals, and the like, where a patient is entirely confined for long periods, is it necessary for health. Temporary exposure to such polluted air is not injurious; but repeated exposure for prolonged periods is extremely injurious to sick and healthy alike. Probably, CO_2 by itself is not, in the above quantities, very deleterious; but it is the only easily tested impurity, and is thus the best index. The disagreement among physiologists as to its poisonousness relatively to the exhaled organic matter and aqueous vapour does not affect its value as a practical test. The "close" smell of over-occupied or overcrowded rooms is probably due to organic effluvia from breath, mucous membranes, or skin; the concentration of CO_2 is an index of the concentration of other impurities.

Third, Environmental Pollutions—Coal-gas, Oil, etc.—(a) Coal-gas.— One cubic foot of gas when consumed is equivalent in polluting effect (in terms of CO_2) to one adult person. Each gas-burner in common domestic use consumes from 4 to 5 cubic feet per hour, and is, therefore, equivalent to 4 or 5 adults. Three ordinary gas-lights in a room are equivalent to the presence of 12 to 15 additional people. If the products of combustion mix with the room-air,—the commonest case,—then, in order to keep the CO_2 down to respirable limits, 1800 cubic feet of fresh air per hour must be supplied for each cubic foot of gas burned. This is approximately the same amount as that required for an adult breathing in a room of 1000 cubic feet. Put otherwise, one person requires 3000 cubic feet of air per hour; 1 cubic foot of gas burnt requires 1800 cubic feet of air; 5 cubic feet require 9000 cubic feet. Coal-gas, unconsumed, is poisonous; minute escapes are very dangerous. The ingredients of unburnt coal-gas are, methane (CH_4) or marsh-gas, ethylene (C_2H_4), or olefiant-gas, acetylene (C_2H_2), hydrogen, carbon monoxide, nitrogen, vapours of volatile liquid hydrocarbons, and vapour of carbon bisulphide. Of these, all, except hydrogen, nitrogen, and the hydrocarbon vapours, are in various degrees poisonous. When burnt, coal-gas yields also CO_2 and sulphur dioxide. Consequently, coal-gas, burnt or unburnt, is always an impurity in the air of a room.

(*b*) *Gas-stoves.*—Gas-stoves are simply large gas-burners (usually Bunsen's burners). They may burn from 5 to 40 or more cubic feet per hour, producing corresponding pollution. To prevent this, flues are absolutely necessary. The "condensing" gas-stoves are said not to pollute the air; but carbon dioxide—one of the chief products of combustion—is not removed in the liquid due to condensation. Nor can combustion proceed without oxygen. Consequently, the condensing stove does not collect all the impurities and does abstract the oxygen.

(*c*) *Paraffin Oil.*—According to Notter and Firth, 1 lb. of paraffin oil requires 138 cubic feet of air for complete combustion, and in polluting effect is equivalent to 15 cubic feet of coal-gas. An ordinary oil-lamp requires as much air as a gas-jet burning 4 or 5 cubic feet of gas per hour.

(*d*) *Candles.*—One candle requires 150 cubic feet of air per hour if the air is to be kept sufficiently pure.

(*e*) *Stoves.*—Closed coal-stoves are liable, especially when over-heated, to emit carbon monoxide—which is extremely fatal. Charcoal-stoves have the same effect.

(*f*) *Drain-air.*—Drain-air, or sewer-air, may sometimes find access to occupied rooms. Such air may contain hydrogen sulphide, ammonium sulphide, carbonic acid, and fœtid organic vapours.

(*h*) *Dust.*—Dust is always a pollution; but cannot always be eliminated; the very fine dust never can be. The grosser dust, which may consist of illimitable varieties of filth from sinks, water-closets, skin, unclean utensils, unwashed clothes, over-used blankets, befouled floors, floor-deafening, dirty carpets, epithelial scales, voided mucus, bacteria, etc., can be effectually rendered, at least temporarily, harmless by wet-cleaning or spraying.

Fourth, Standard of Air-purity; and Quantity of Air necessary to maintain it.—Cubic Space.—The standard of air-purity aimed at varies with the nature of the premises to be ventilated. The physiological ideal is: a maximum of 6 volumes of CO_2 per 10,000 volumes of air, that is, 2 volumes above the 3·5 to 4 volumes existing in average air. But this standard cannot be maintained except where the air supplied constantly amounts to 3000 cubic feet per head per hour, or where the CO_2, with the other impurities, is directly removed before it diffuses into the air of the room. Now, the ordinary methods of ventilation rarely secure 3000 cubic feet of air per head per hour, either in a private dwelling-house or in work premises. Without a specially adjusted system of ventilation, it is not possible to provide this amount of air, or to diffuse it uniformly through the occupied premises. Hence, in practice, a compromise has to be made between the temporary ill-effects of air polluted beyond the 6 parts of CO_2 per 10,000, and the discomfort or ill-effects due to cold draughts, or to excessive radiation of body-heat to cold objects in the room. The excessive radiation of body-heat to cold solid objects, or to objects persistently cooled by evaporation from moist surfaces, or to thin exposed walls, or to windows, is as important a cause of discomfort as exposure to draughts. If the solid objects in a room are warm, cold draughts are easily tolerated, and may be even pleasant. Radiation is, of course, independent of air-currents; heat rays pass, like light, in straight lines in all directions equally from the centre of radiation, and are absorbed or reflected according to circumstances. Hence the necessity of combining ventilation with warming, not necessarily with warming of the air, but with warming of the solid objects. If the body is clothed in good, non-conducting clothes, and the room-objects are warm, cold air is not injurious. The "open-air" treatment of phthisis is a standing demonstration of this. It may be called treatment by large draughts.

It is, however, for ordinary life, in limited spaces, difficult to provide without discomfort the requisite quantity of air, which increases with work. Thus an adult male during work requires 9800 cubic feet of air per hour; during repose, 3600 cubic feet; an adult female, in repose, requires 3000 cubic feet; a child, in repose, 2000 cubic feet. In practice, less than this must be accepted. Morin lays down the following approximations:—

Amounts of Air Necessary per Person per Hour

Hospitals (ordinary) . . .	2000 to 2400 cubic feet per hour.
„ (epidemic) . . .	5000 „ „ „
Workshops (ordinary) . . .	2000 „ „ „
„ (unhealthy) . .	3500 „ „ „
Prisons	1700 „ „ „
Theatres	1400 to 1700 „ „
Meeting Halls	1000 to 2000 „ „
Schools (per child) . . .	400 to 500 „ „
„ (per adult) . . .	800 to 1000 „ „

Haldane recommends for factories and workshops a maximum standard of 12 volumes CO_2 per 10,000 volumes of air where no gas is used, and 20 per 10,000 where gas is used.

To secure this standard, 1250 cubic feet of air per hour per person must be supplied. He bases this estimate on the fact that about 1 cubic foot CO_2 per hour is produced by a man at work. He has found that even in very badly ventilated workshops the amount of CO_2 rarely surpasses 50 volumes per 10,000, and that it takes six times this amount to interfere seriously with respiration. Professor Thorpe (see Jacob's *Ventilation and Warming*, p. 14), found in a sitting-room, near floor, 7·33 CO_2 per 10,000; half-way up, 9; near ceiling, 14·65. In the Grand Theatre, Leeds: pit, 15·01; upper circle, 14·29; balcony, 14·16. In the Philosophical Hall, after lecture, 13·38. Professor Clowes, in Nottingham (*ibid.* pp. 14, 15), found in the chemical laboratory of University College, 6·9; in the grounds of the College, 4·3; in the Masonic Hall during a dance, 31; in the Circus, 32·6; in a committee-room with 15 persons and 27 gas-jets, 41·8. Dr. Angus Smith, in three Manchester mills, found (1) with 400 people, 28·6; (2) with same number, 29·6; (3) with same number, 30. Recent results confirm these analyses.

Cubic Space.—If the impurities of each expiration could be instantly removed, and fresh air supplied directly for each inspiration, the amount of cubic space for inhabited rooms would be of little moment. But the expired impurities diffuse rapidly through the surrounding atmosphere, and the only mode of keeping them down to respirable limits is to dilute them freely with fresh air. To do this without draughts is difficult in a small space. Hence a minimum space compatible at once with fresh air and comfort must be fixed. For dwelling-houses, this cannot be fixed precisely; but the standard for common lodging-houses, namely, 400 cubic feet per bed, may be applied to individual houses. The following table indicates the amount of space required by statute, or order, or otherwise found desirable for various types of building:—

Minimum Floor Space and Cubic Space in various Buildings

	Floor space in square feet per bed.	Cubic space in cubic feet per bed.
Barrack-room, occupied day and night	50-80	600
Common lodging-house	42	300-400
Factories and workshops—		
Ordinary hours	...	250
Overtime	...	400
Special trades, by order of Secretary of State	...	various
Hospitals—General	90-140	1200-1600
Maternity	100-140	1200-2000
Infectious disease	140-200	2000
Poorhouses and workhouses—		
Sick	72	850
Lying-in women	100	1200
Offensive cases	...	...
Infirm persons occupying same room day and night	...	700
Infirm persons able to leave dormitory during day	42	500
Healthy persons	42	300
Prison cells for continuous confinement	80-120	600
Schools—Day schools	8	80
Dormitories	50-60	400

Unless properly ventilated, a large cubic space becomes ultimately as much fouled as a small. All the above quantities presuppose the most adequate ventilation. Floor space is very important: (*a*) because it is essential to management; (*b*) because it minimises contacts in infection. Height should not exceed 14 feet, unless there is a ceiling ventilator; a greater height tends to cool the fouled and heated air, and thus cause it to re-mix with the air of the room. Where gas is freely burned, the heat of the combustion practically makes a separate circulation above the level of the gas-jets; the result is the same as if the ceiling were lowered to that level (Shaw).

Fifth, Dynamics of Ventilation.—Practical ventilation is an engineering problem, the conditions of which are never twice the same. This is obvious from the following enumeration of premises needing ventilation:—Dwelling-houses, including cellar-dwellings, one-roomed, two-roomed houses, one storied, back-to-back, tenements of flats, semi-detached and detached villas, mansion-houses, common lodging-houses, poor-houses, work-houses, prisons, —all being occupied for the greater part of the twenty-four hours; Schools, day-schools, night-schools, lit by gas or lamp—all being occupied for several hours continuously; Churches and meeting-halls—being occupied for two hours or more by persons in repose; Drill-halls, gymnasia, etc.—being occupied for longer and shorter periods by persons in great activity; Workshops and factories—being occupied for twelve hours or more continuously in varying conditions as to dust, dampness, trade effluvia, etc., by persons active and passive; Hospitals, occupied by the sick—including general hospitals, maternity hospitals, infectious disease hospitals, sanatoria for consumption, etc. No single system is equally applicable to all these, not to speak of ships, canal-boats, mines, etc. The fundamental principles, however, are the same for all.

The physical theory of ventilation may be stated in two propositions: (*a*) Given a "head of air," then a continuous flow of air through a room can be maintained, the quantity of air entering by all inlets being exactly equal to that issuing by all outlets; (*b*) a "head of air" is produced by difference of pressure between the air within and the air without a room. Air is not alive; it will not move of its own accord.

From these two principles, it follows that the essence of ventilation as a physical problem is how to produce such a head of air as will cause a required quantity of air to flow continuously at a required rate through a room, with given inlets and outlets. In practice, the problem is how to provide each person with approximately the quantities of air specified in the above tables.

Sixth, Systems of Ventilation: Ventilating Mechanisms.—Systems of ventilation may be classified into (A) Vacuum Systems, and (B) Plenum Systems,—these terms representing the two fundamental methods of producing a "head of air," with the consequent flow of air into and out of the room. The common division into "natural" systems and "mechanical" systems is peculiarly inept; since the so-called "natural" systems are highly artificial, and the "mechanical" systems involve precisely the same principle, namely, alteration in air-pressure, as the "natural" systems.

(A) VACUUM OR EXTRACTION SYSTEMS

(*a*) *Open Fire with Flue.*—The heat of the fire expands the volume of air in the chimney, reduces the density, so causes an upward flow, which in turn causes a flow in the room-air. The air removed must be made good by air from without. The chimney is the outlet; the inlets are all other openings, including cracks, crevices, doors, windows, etc. The ventilating efficiency depends on the difference between the temperature maintained in the chimney and the temperature of the air outside.

The following table from Morin indicates the extraordinary capacity of the open fire as a ventilator.

Relative Size of Chimney Flue for different Rooms

Cubic capacity of room in cubic feet.	Volume of air to be removed by the chimney per hour in cubic feet.	Area of section of rectangular chimney flue in square feet.	Diameter of section of cylindrical chimney in feet.
3,500	17,500	·99	·88
4,200	21,000	1·19	·98
5,300	26,500	1·48	1·08
6,350	31,750	1·78	1·21
7,750	38,750	2·17	1·31
9,200	46,000	2·57	1·44
10,600	53,000	2·97	1·54

The open fire is a compromise between a ventilator and a heater. To secure the best results for ventilation, without sacrificing too much heat, "Morin recommends that the temperature of the air in the chimney be maintained at about 45° Fahr. above the external air, and the velocity of the smoke issuing from the chimney should be about 10 feet per second, in order to secure stability in the draught, and that the chimney should be capped with a cone-shaped top—the area of the orifice of discharge to be one-half that of the chimney" (Shaw in *Stevenson and Murphy*, vol. i. p. 126). From the table it is seen that a ward of 10,600 cubic feet, which would accommodate from five to six infectious patients at 2000 cubic feet per patient, may, by a rectangular flue of less than 3 feet square, or a cylindrical flue of 1½ feet square, have an air supply of 53,000 cubic feet per hour drawn through. Thus if the inlets are of the proper size and properly placed, each patient may be supplied with from 9000 to 10,600 cubic feet of air per hour, which is three times more than the amount theoretically necessary. Allowance, however, must be made for irregularity of draught, closing of inlets, sinking of fire, etc. Where gas-jets are the heaters, the current may be kept constant, provided the temperature is maintained in the flue.

(*b*) *Ventilating Grates or Stoves.*—Where the fire-places are "ventilating grates," such as Galton's, or the Manchester Grate, the same quantities of air may be obtained with flues of less dimensions. For rectangular flues, the areas, taken in the same order as in the above table, would be:—0·54 sq. ft., 0·66, 0·81, 0·97, 1·2, 1·4, 1·6. For cylindrical flues:—1·5, 1·8, 2·3, 2·7, 3·3, 3·9, 4·6 sq. ft. The ventilating grates not only extract the air, but also admit air, and warm the air admitted. Consequently, a ventilating grate will maintain a circulation of air in a room that has no other outlet or inlet.

Ventilating gas-stoves, such as Bond's Euthermic or George's Calorigen, are designed to fulfil much the same functions as the ventilating grates, and for halls, lobbies, consulting-rooms, and the like, are extremely convenient. Why ventilating grates and stoves (coal, gas, and oil)—though suggested by Dr. Neil Arnott, two generations ago—have not yet become as common as open grates, can be explained only by the inertia of unscientific habits of house-building, and the popular craze for non-essentials in a house. Already, however, there are several good patterns in the market. (See Notter and Firth, 2nd ed., p. 239 *et seq.*).

(*c*) *Ventilating Shafts.*—These, unless fitted with an extraction fan, or steam-jet, or other motor, depend for their efficiency on three circumstances,—the aspirating effect of air-currents across the top, the height of the shaft, and the difference between the temperature within the shaft, and the temperature without. All three factors operate in the ordinary chimney with fire-place, where the difference in temperature is created by the fire. Gas-jets or hot-pipes may be made to serve the same purpose. The velocity of the air-current may be calculated from the height of the outlet opening above the inlet opening, when the temperature within and without the shaft is known. The engineering tables show the velocities corresponding to given heights of shaft, at given temperatures. Thus with a shaft 30 feet high, where excess of temperature in shaft is 50° Fahr. above external air, the velocity of air-current will be 14 feet per second.

(*d*) *Cowls.*—In so-called "natural" ventilation, which is only the general case of which a ventilating shaft is the special, cowls are sometimes placed on the outlet. The design usually is to "increase the draught"; but, as shown above, the draught depends on the head-of-air produced by temperature, or aspiration by wind, etc. No cowl has an active effect. The chief value of a cowl is to prevent foreign bodies, or birds, or rain, or snow, from entering the shaft. When wind is blowing, they prevent down-draughts, provided the head-of-air at the lower end of the shaft is not greater. To suppose that they always cause up-draughts, and always prevent down-draughts, is neither good observation nor sound theory. The varieties of cowl are numbered by the score. Some are rotatory, being fitted with an Archimedean screw; they are active in a high wind, when they are useless, and stationary and obstructive in a calm, when they are wanted. Some are so moved by a vane as to keep the opening always on the lee side, so assisting extraction of air. Some are static, as in Boyle's, or Donald's or Buchan's. The openings are so flanged that the wind from any direction causes aspiration upwards. Hellyer found Buchan's the most effective. Billings prefers the simple conical cap, or rather truncated cone, with fixed plate above; it is one of the oldest forms, and one of the cheapest; it gives the greatest velocity, and offers least resistance. The top plate prevents in-dropping of rain or other foreign matter.

(*e*) *Inlets and Outlets.*—For inlets, the trumpet-shape, with large end inwards, secures better diffusion than a tube of uniform calibre. When a grating covers the inner end, the holes should be bevelled on the side *from* which the air is blowing. As to size, inlets should be "capable of being one and a half times as great as the outlet" (Shaw). This secures less friction and less draughtiness. As to structure, inlets should be as unobstructed either by bends, or gratings, as possible. A right-angled bend on an inlet duct reduces the velocity of the incoming air by about 50 per cent. Inlets should be adapted for regulation. Thus Sheringham's Valve, which is shaped to direct the air upwards, can be closed or opened to any degree. A double-sash window can, by pushing up lower sash and blocking the lower opening, be made to admit air upwards between the sashes (Hinckes-Bird). But shape or direction is less important than position. Galton's grate is a good type of well-placed inlet and outlet. The inlet admits warmed air near the ceiling; the air diffuses easily in the upper strata, passes to the far side of the room, descends, runs along towards fire, and then up the flue. Inlet and outlet are on the same side of the room, and this arrangement secures the best diffusion, provided other openings do not interfere. If air be admitted at floor level, it should be warmed. Forms of inlet are:—Sheringham's valve; Steven's drawer, which is much the same in principle; Jenning's air-brick, placed near ceiling; Mackinnell's ventilator, which consists of an inner tube within an outer, the inner taking heated air from ceiling, the outer admitting cool air; Tobin's tube, which admits air from ground level, and carries it along duct vertically to any height within the room. Of the last, the primary defect is the taking of air from ground level. Dust is apt to lodge in the tube, which is usually unheated and too long. Tobin's tubes are best made of metal, which heats more readily to room temperature. Steam or water heated radiators, placed opposite simple openings at floor level, secure good ventilation, *e.g.*, in hospitals. Mixing boxes (Jacob's and others) have been designed for warming air on admission. Inlets may be placed behind cornices or pictures. They should, as a rule, be placed more than six feet high. In mechanical systems of ventilation, the ratio in size of inlets and outlets must be adjusted to the special system,—the quantity of air, the velocity, etc.

Outlets.—These have been already indicated. A fire-flue is the chief domestic outlet. As a general principle, outlets should be reduced where possible to one; friction will be less, there will be less risk of contrary action between outlets, and efficiency can be better regulated. In exhaustion systems a fan or steam-jet may be placed in the outlet. Sometimes, as in one form of Arnott's valve, an opening is made into chimney at ceiling level, the opening being guarded by a mica-flap valve to prevent regurgitation of smoke. This is good in certain forms of room, as where windows or doors are the main inlets. Sometimes a flue for air is made vertically parallel with chimney, with an opening at ceiling level. They act well, provided inlets are sufficient. Mica-flap valves are noisy in windy weather.

(B) Plenum or Propulsion Systems

In a Plenum system, the air is forced into the rooms by mechanical power—rotating fans, "fanners," or blowers—or by steam-heated coils, stoves, furnaces, water-spray, steam-jets, or other heat-producing appliances. The Galton grate is at once a vacuum and a plenum appliance, forcing in warmed air and exhausting fouled air. In America the heating furnace for forcing in hot air is a very common house-fitting.

For large rooms, or buildings like schools, factories, hospitals, and the like, where cubic space per head is necessarily small, a mechanical system of Plenum ventilation is frequently the best. For large schools, it has emerged as the best. But its suitability depends on the skill of the designing engineer. A Plenum system (Key's) may be seen at work in many Scottish schools: in particular—Aberdeen Board Schools, Dundee Board Schools, the Leith High School, the Victoria Hospital (Glasgow), the Govan Parochial Hospital, and elsewhere. In Key's system, the parts are arranged in the following sequence:—Inlet, louvred or otherwise protected; screen for washing and filtering the air; forest of steam-heated pipes, arranged in sections or groups for greater or less heating; rotary fan, driven by steam, or oil, or gas, or water, or electricity; horizontal main air-duct; horizontal branch-ducts; vertical sub-branch-ducts, with doors and extra heating-coils; openings near ceiling in rooms; outlet near floor; vertical duct, opening to outside. The air drawn or driven in by the fan passes through all those structures in the order given. The walls and windows are hermetically sealed. The air can be regulated in amount, in temperature, and in humidity. The system requires the attention of a competent mechanic. It is at once a system of ventilation and a system of heating. A special feature of the system is the placing of inlets and outlets on the same side of the room—the inlet near the ceiling, the outlet at or in the floor. In winter, the outlet at the floor level is found best; in summer, the outlet near the ceiling is found best (Billings).

The system is costly, both in installation and in use; but when properly arranged and properly managed, it is efficient. There are many other varieties of mechanical systems, *e.g.* the Sturtevant system, the Blackman system (Blackman's fan is commonly used in Key's system), and so on. As already noted, mechanical power can be applied for extraction as well as for propulsion.

Carnelley and Haldane, after an elaborate investigation, decided in favour of mechanical ventilation of schools. The comparative efficiency of "mechanical" and "natural" (or temperature ventilation—shafts, cowls, chimneys, etc.) is shown below, the mechanical system being taken as unity:—

Excess over Outside Air.	Dundee Schools (Carnelley, Haldane, and Anderson).		Aberdeen Schools (Brazier, Thomson).	
	Mechanically Ventilated.	Naturally Ventilated.	Mechanically Ventilated.	Naturally Ventilated.
Temperature . .	1	0·66	1	0·9
Carbonic acid . .	1	1·7	1	1·6
Organic matter .	1	7·0	—	—
Micro-organisms .	1	9·2	1	7·2

These results leave no doubt of the superiority of the mechanical systems. "By mechanical ventilation the whole of the air in a school may be easily changed in less than fifteen minutes, and when the system is well arranged, in less than ten minutes." The same observers prefer "blowing in" (propulsion) to "exhausting" of air, because in the propulsion system the source of the air admitted can be better controlled and the air better distributed.

Notes on Warming.—The following notes are supplementary to the details given under "Ventilation."

(1) *Open Fires.*—Advantages are—cheerfulness and good extraction of air. Defects are—great wastefulness (about 80 to 90 per cent) of fuel and production of floor draughts. In meeting these defects, very few of the many devices are entirely successful. A good grate should have little or no iron in its structure. The ribs should be thin and vertical, not thick and horizontal. The back and sides should be of fire-clay. The sides should make an angle of about 120 degrees with the back; a line at right angles to the posterior edge of one side should just clear the anterior edge of the other; the heat from each side will thus be radiated into the room. The back should overhang, so that upper margin at chimney throat should be nearly as far forward as margin of grate bottom. If practicable, the grate should stand forward into the room. The air should circulate round it. A movable damper or regulator should control the chimney throat. The slits between the bars of the bottom grid should be narrow. The passage of air through them should be controlled by a tight-closing ash-pan or a "Teale's economiser." A still simpler method of control is a piece of sheet-iron slid in to cover the bars. This makes the fire burn more slowly, and can be used as a regulator for almost any grate.

The following patterns realise these conditions in various degrees:—The Nautilus grate, which stands out in the room, slow or quick combustion, chimney-throat regulator. The Galton grate, or stove, already described. The Grundy grate, fire-clay back, same principle as Galton's. The Teale grate, air-chamber below grate, no air admitted through bottom grid, very thin vertical bars in front, other conditions as above enumerated, two patterns, ordinary and front-hob, air in latter admitted at fire level; these patterns common in Yorkshire. The Rational grate, sunk ash-pit. Boyd's grate, same as Teale's with adjustable canopy at chimney-throat, regulating ash-pit, no iron parts; air circulates round whole grate. Heim's "Helios" smoke-consuming grates, fire enclosed, shines through mica, very economical, less cheerful than open fire, but convertible into open fire at will. Heim's "Hestia" stove, smokeless, economical, suitable for halls, etc. Neil Arnott's grate, practically smokeless, fuel burns from above downwards, coals put in first, lit from top, bottom movable upwards by capstan mechanism, chimney-throat valve, very economical, needs almost no attention for six to twelve hours continuously. Arnott's stove, double-cased, fed from top, anthracite coke, automatic air-valve, burns from twelve to twenty-four hours without attention, very economical, suitable for entrance halls, may be used as ventilator also. Arnott suggested opening into chimney at ceiling level for hot foul air removal. Falkirk Iron Company's "controlled combustion air-chamber heating apparatus," claims to heat room of 40,000 cubic feet sufficiently (with gas-coke, 2 lbs. per hour), at less than twopence per hour. Shorland's grate, ventilating, same principle as Galton's, common in hospitals. Shorland's calorigen, for heating rooms from under floor level.

(2) *Stoves.*—Advantage: greater economy; defect: less cheerfulness,

danger of carbon monoxide formation from coke and coal stoves. For good patterns of coal or coke stove, see under (1). Oil (paraffin or petroleum) stoves are convenient for small rooms. A flue is always advisable. Gas-stoves should always have a flue. Many varieties. Best are radiant heat and ventilating forms. The "ball-fire" fitted with gas-burner, in ordinary grate, very wasteful. When stove is fitted, chimney access should be perfectly closed with sheet-iron, containing opening only for flue. All ball-fires waste heat by inter-radiation among the irregular balls (see Thos. Fletcher, *Coal-gas as Fuel*). Many patterns provided by gas companies; advisable to test by experiment before selection.

(3) *Heating by Steam, by Hot Water, and by Combination.*—Hot-water systems may work with high pressure (*e.g.* Perkins' patent), or with low pressure. In the former, the pipes are of wrought iron and small, about 1½ inch diameter; in the latter, about 3 to 4 inches diameter. Length of pipe necessary for given size of room, calculated by experiment. Thus Hood found that, with temperature of pipe at 200° Fahr., and temperature of external air at 40° Fahr., it is necessary, in order to heat 1000 cubic feet per minute up to 60° Fahr., to have at least 80 feet of 4-inch piping. Hood's tables give too low estimates. Radiators are an important factor. They vary in efficiency (see Carpenter, *Heating and Ventilating Buildings.*) When steam is available, it may be used to heat a "calorifier" (spiral condensing tube passing through water). This in turn may be used to form low pressure circulation. Waste steam frequently available. Heat liberated on condensation proportionally very great. All these systems may be applied to warm the admitted air. Important to warm the walls (see Galton's *Healthy Dwellings*, p. 184 *et seq.*)

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Verruga Peruana.

Synonyms.—Verruga Andicola, Peruvian wart, bouton des Andes, la maladie de Carrion, fievre delà Oroya, fièvre maligne de "las quebradas."

Definition.—A general infective disease, peculiarly limited in distribution, and usually marked by anæmia, severe constitutional disturbance, and the subsequent development of a characteristic skin eruption.

History.—As far back as the sixteenth century verruga apparently attacked the Spanish soldiers at Coaque (Ecuador) and in Puerto Viego and Cusco, but of late years it has never established itself outside certain deep-cleft inland valleys on the western slopes of the Peruvian Andes in the department of Ancachs, Lima, and Libertad, between 8 and 13 degrees of latitude, and at elevations of 1400 to 9000 feet. Although Haviland Hall heard from Zaruma (Ecuador), of a mild outbreak of very similar disease, and Beaumanoir reported a solitary case in Reunion, in neither case did it spread. In 1870 the outbreak of fever among the Trans-Andean railway constructors, which Espinal suggested was a phase of verruga, aroused fresh interest; and in 1885 Carrion, a Lima student, threw additional light on the subject by inoculating himself with blood from a verrugous tumour, and producing a fatal disease strongly resembling this "Oroya" fever. His experiment gave strong evidence in favour of the identity of the two diseases (a view supported by clinical experience), and also went far to prove the inoculability of verruga.

Etiology.—That verruga is inoculable is certain, but it cannot be highly contagious, as cases are treated in general wards. The very young, if attacked, are apt to suffer from the graver forms, whereas the elderly enjoy a certain immunity from these (odriozola), but sex has no influence. Unlike yaws, the disease is by no means confined to coloured races, but the actual inhabitants of the endemic areas acquire some immunity, while the new arrival is particularly liable to suffer. Malarial infection frequently obscures the clinical picture, but has no ætiological significance. Like that disease, however, but more markedly, verruga is confined to certain districts, while its outbreaks bear distinct relation to soil disturbance, and coincide with the drying of the soil after floods. The endemic valleys have rocky sides and earthy bottoms, and the streams which traverse them overflow twice a year. From the stillness of the atmosphere and the high temperature their vegetation is tropical even at considerable altitudes. The water itself has often been suggested as, and is popularly supposed to be, the source of infection, but is probably guiltless, although its floods no doubt exercise a subsidiary influence. The connection with soil-disturbance and frequent occurrence in soil workers suggest a telluric factor in causation; and Firth, on account of the prevalence of helminthiasis, mentions the possibility of an association with some worm passing its free state in mud. From the peculiar limitation, some local condition, perhaps the physical features, evidently plays an important part in development; and the infrequency, mildness, and apparent inability to spread of cases occurring elsewhere points the same way. An organism seems by far the most probable cause, and the limitations of tsetse fly disease, and the recently discovered connection of malaria with mosquitoes, suggests the possibility of a somewhat analogous conveyance of infection by insects peculiar to these districts.

Symptoms.—The incubation period is not yet accurately determined, and may last from a week to two months or perhaps more; Odriozola gives the average as about forty days. Vague pains, chills, and alimentary disturbances, with gradually increasing anæmia, enfeeblement, and slight nocturnal fever, constitute the common prodromal symptoms. Of the developed disease there are two manifestations: the constitutional disturbance and the eruption. Both usually occur, but at times the first is hardly noticeable, and, on the other hand, is occasionally so profound that death ensues without any appearance of eruption, constituting the grave form or Oroya fever. If the eruption disappears too rapidly very similar symptoms may supervene, even without internal verrugæ. The onset is usually marked by chills and irregular, remittent, or intermittent fever, often accompanied by profuse sweats. There is profound prostration, anorexia, thirst, and frequently marked gastric irritability and hiccough. The tongue is pale and flabby. More characteristic, however, are the extreme and rapidly produced anæmia, the intense headache, muscular cramps, and bone and joint pains, and the frequent tenderness and enlargement of liver, spleen, and lymphatic glands. The red cells and hæmoglobin are diminished, and there is a leucocytosis. From anæmia there results pallor, or (from blood destruction) an icteric complexion, marked vertigo, or even syncope, cardiac murmurs, quickened pulse and respiration, œdema and tinnitus, insomnia and dreams. The pains, dull or acute, are worse at night, and especially involve the extremities. Very rarely there is slight joint swelling. Cases are often complicated by hæmorrhages, particularly epistaxis or petechiæ, serous diarrhœa, or pulmonary congestion. With gradual fall of temperature the general condition may improve and recovery follow, but severe cases proceed with continual or occasional falling temperature, increased restlessness and low delirium, and end in coma and death, hastened perhaps by pulmonary or intestinal complications.

Eruptive Phase.—Usually this supervenes after an interval of one or two months marked by vague "reminders," such as pains or slight fevers. It may, however, coincide, or to some extent alternate with the general symptoms, or even precede them. Its time of appearance, duration, and degree of exuberance bear distinct relation to the severity of attack, and when scanty or delayed render prognosis graver. Constitutional manifestations are less severe than in non-eruptive cases, and lymphatic enlargement, vertigo, and vomiting are rare, but œdema (resulting from the eruption) is more marked. The clinical features may, however, be altered by the development of verrugæ in internal organs. The two types of eruption may occur separately or together. The smaller (superficial) commence in the superficial layers of the skin as petechiæ, shining transparent spots, little horny elevations, or rarely as vesicles or pustules (odriozala), and enlarge into little reddish shining tumours from a pea to an orange in size. They are sessile or pedunculated, discrete or confluent, localised or general, and usually appear in crops. The limbs, face, and neck are chiefly involved, the trunk, palms, and soles being less liable. Prickling sensations sometimes precede them, and itching is often extreme. Many are very vascular and readily bleed, others may ulcerate and exude a brownish fluid, which forms a crust under which they heal, or they gradually pale, desquamate, and disappear. Not only do they involve the skin, but also the conjunctiva, any part of the alimentary or respiratory mucous membranes, the connective tissue of the parenchymatous organs, the muscles, periosteum, or bones, and even the meninges and nervous centres.

The larger (subcutaneous) form are never found internally, and commence in the subcutaneous connective tissue. Invisible but palpable nodules appear which become adherent to the skin, causing reddening and tenderness and finally rupturing, and appear as reddish painful tumours with offensive discharge, and spherical, conical, mushroom-like, or irregular in shape. Their size varies from that of a nut to that of an apple, and they are sessile or pedunculated. Vascularity is a marked feature, and hæmorrhages, sometimes dangerous and always increasing the anæmia, are not infrequent. Rarely the initial swelling simulates fluctuation, but from the entry of pyogenic organisms actual suppurative foci, ulceration, and even gangrene may arise. The growths have an especial predilection for the face, knee, and back of hands, especially over the metacarpo-phalangeal joints of thumb and index finger; the trunk is again less liable.

Course and Sequelæ.—This stage of eruption generally lasts four to six months, but with intermissions may even last two years or more. Generalised cases are usually more rapid. In most cases the growths shrivel or ulcerate and gradually disappear, but considerable anæmia and debility are left, and neuralgias are often troublesome. Profuse hæmorrhages, entry of pathogenic organisms, or some other complication, may cause death, and the mortality at periods of exceptional prevalence is great. Although one attack is supposed to confer immunity recurrences have been reported.

Morbid Anatomy.—In non-eruptive cases the dominant features are the anæmic condition (with the exception of localised congestions of lung or elsewhere) of all organs, and the fluid and slowly coagulating blood. The liver, from destruction of red cells, is frequently dark coloured, the lymphatic and mesenteric glands and Peyer's patches are enlarged, and there are signs of activity in the bone marrow.

The tumours arise from the connective tissue of the skin or elsewhere, and are essentially composed of a mass of embryonic cells with large nuclei, some polynuclear leucocytes, and a few fixed cells, supported by a delicate fibrous stroma. The epidermis over them is infiltrated with leucocytes, and in the ulcerated cases foci of suppuration are seen. The vessels are often large, numerous, and distended with blood; they may appear as if hollowed out of the tumour mass, and small hæmorrhagic foci may be present. According to Letulle the lymphatics are dilated, and Nicolle, contrary to the general experience, claims to have found giant cells and caseation in internal verrugæ.

Bacteriology.—Bacilli have been found by Isquierdo and Letulle in the depths of the non-ulcerated skin tumours, and by Nicolle in internal verrugæ. They somewhat resemble the tubercle bacillus and, after prolonged staining, resist, as it does, the decolorising action of acids. They are sometimes intracellular (Nicolle). Various kinds of pyogenic cocci, probably from secondary infection, have also been found in the ulcerative lesions. Florez obtained chain cultures of cocci by inoculating agar-agar with verrugous blood, and Odriozola found in the grave febrile forms a very short bacillus, only colourable by Loeffler's stain, until after cultivation in bouillon, when it was larger and stained readily. Up to the present, however, all attempted inoculations of animals with these organisms have failed, and the bacteriology is therefore indefinite.

Diagnosis.—This presents little difficulty except in non-eruptive cases or in the pre-eruptive stage. In Peru residence in the endemic districts must always be carefully inquired into. Malarial fevers, which are frequently simulated, are best distinguished by blood examination, but the presence of the plasmodium is not conclusive against verruga, as the diseases sometimes co-exist. The inefficacy of quinine, the more rapidly-produced anæmia, the glandular enlargement and vertigo, with the localised pains and less marked splenic involvement, are therefore additional distinctions. Pernicious anæmia, ankylostomiasis, rheumatism, and acute hepatitis can be readily distinguished. The eruption resembles in many respects that of yaws, but the latter is a disease of low lands, attacks coloured races almost exclusively, is more contagious, has no local limitations, and is acquired quite differently. The general symptoms, too, are hardly noticeable, the growths are never found internally, and it is chiefly prevalent in early youth.

Lastly, unlike yaws, animals can be inoculated with verruga and suffer from a similar disease, and there are cases recorded of apparent infection "in utero," which is at least doubtful in yaws.

Prognosis.—With severe constitutional symptoms and repressed eruption, especially with a comparatively low temperature, or where pulmonary complications supervene, prognosis is extremely grave. So also are cases with symptoms pointing to verrugæ in important organs, while the most favourable cases are those with early development and gradual retrogression of eruption with coincident general improvement.

Prophylaxis.—This consists in the avoidance of endemic areas by newcomers, especially at periods of prevalence and when the soil is being disturbed.

Treatment.—Removal, if possible, from the endemic area and to a warm place at sea-level is the first indication, as cold represses the eruption, and low barometric pressure favours hæmorrhage. In severe cases diet should be nourishing and easily digested, and drugs by the mouth avoided, if possible, in order to prevent disturbance of digestive function. There is no specific treatment, but Odriozola recommends the administration in milder cases of arsenic and iron. He also thinks a decoction of maize a useful diaphoretic, and recommends oxygen inhalations and, for the obstinate headache, iced compresses. Cold bathing is contra-indicated, but the skin must be kept clean and aseptic, and any ulcerating or gangrenous growths ligatured or excised. Complications must be treated on ordinary principles, but styptics, compresses, and transfusion apparatus should be at hand in case of hæmorrhage.

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Vertigo.

Except when the body is at rest and when equilibrium is maintained, as in any mass of inert matter, by the ordinary laws of gravity, equilibration is normally effected by muscular activity. The muscles specially concerned in the maintenance of equilibrium are those of the head, neck, spine, and lower limbs, all of which are innervated by the cerebral cortex, acting largely under the influence of the cerebellum.

The cerebellum is a co-ordinating centre to which are transmitted various centripetal stimuli, affording information as to the relation of the body to surrounding objects. The chief afferent impressions are (1) those from the semicircular canals of the internal ear, whose endolymph exercises a varying pressure upon the end-organs there, under the influence of movements of the head and of gravitation; (2) those from the skin of the parts on which the body is resting; (3) those from the muscles and joints concerned in maintaining the posture, especially the muscles of the spine and lower limbs; (4) those from the muscles moving the head and eyes, which indicate the relation to the body of objects seen. The cerebellum, receiving impressions from all these various peripheral sources, exercises in turn an efferent action upon the cerebrum, and thence upon the various muscles which subserve equilibration. A direct influence of the cerebellum upon the spinal muscles has been described by some, the hypothetical cerebello-spinal paths being through the nuclei of Deiters, and thence by the vestibulo-spinal tracts to the cord. More probably, however, the cerebellum exerts its influence upon the muscles not directly, but by intermediation of the cerebral cortex. Each cerebellar hemisphere is intimately connected with the contra-lateral motor cortex by means of the corresponding superior cerebellar peduncle, leading from the cerebellar cortex and dentate nucleus to the contra-lateral red nucleus and optic thalamus, and from both the latter onwards to the frontal lobe. That this is the true mechanism is rendered still more probable by the recent researches of Pagano, who, on stimulating one lateral lobe of the cerebellum, obtained movements of the homo-lateral trunk muscles. Such movements were abolished if the contra-lateral motor areas of the cerebral cortex were extirpated.

By vertigo or giddiness is meant that disagreeable sensation which results if the sense of equilibrium is disturbed. The motor act of normal equilibration, once acquired, does not form part of our ordinary consciousness. When an individual has once learned to balance himself, whether standing, sitting, walking, riding, skating, etc., the movements necessary for maintaining that particular posture are, generally speaking, carried out automatically or subconsciously by means of the mechanism already described. It is only when some flaw occurs in this cerebellar mechanism or in the higher centres that the individual becomes aware that something is wrong. The sensation of giddiness then at once arises. This sensation may be accompanied by movement or sense of movement either in the individual himself or in external objects. Reeling or staggering, it should be remembered, is not synonymous with giddiness, but is a motor phenomenon, representing the individual's effort to preserve his equilibrium in the presence of abnormal sensations.

Vertigo may result from affection either of the higher cerebral or of the subordinate cerebellar centres, or it may be due to interference with the normal peripheral impressions to which reference has already been made. But whatever be its cause, whether central or peripheral, the individual does not, as a rule, take cognisance of the particular source to which his vertigo is due. All that he notices is the result upon his consciousness, namely that he feels giddy. Whether the giddiness be due to labyrinthine, ocular, or other peripheral defects, to gross cerebral or cerebellar disease, or to some toxic affection of the centres, is a problem for the physician to solve.

When vertigo is severe, nausea and vomiting tend to become superadded, as in the familiar instance of sea-sickness. Such vomiting has been ascribed by some to connection between the cerebellum and the gastric fibres of the vagus, whilst others trace it to the connection between the auditory and vagal nuclei in the bulb. It may also be due to disturbance of still higher centres, the same centres which perceive the giddiness. It is, in any case, a true cerebral vomiting.

Considerable attention has been paid to the question of whether there is a sensation of movement in the individual himself:—so-called "subjective" vertigo; or whether the apparent movement is in surrounding objects, the individual himself not seeming to move—"objective" vertigo. "The appearance of movement in stationary bodies," says Dr. Hughlings Jackson, "must, as a sensation, depend upon movements of the patient's eyes, occurring involuntarily, and leading to erroneous visual judgments. Where the mental impression is that of movement of the patient's own body, the explanation is not so obvious."

In some cases of vertigo, surrounding objects seem as if they were revolving round the patient, either horizontally to one side or the other, or vertically up or down. The direction generally corresponds to that in which the patient feels himself moving. But sometimes objects appear to move in the opposite direction to that of the subjective movement, as in the vertigo of waltzing, probably because of the direction of movement of images across the retina. In still other cases, surrounding objects seem to move in directions which do not in any way correspond with the subjective vertigo, as, for example, when objects seem to advance and recede, or when each object appears to rotate round its own axis. The explanation of such cases is obscure.

Vertigo in Healthy People.—Before passing on to the various diseased conditions associated with giddiness, a brief reference may be made to certain varieties which scarcely fall within the category of pathology. Thus, for example, the giddiness produced by the passage of a galvanic current transversely through the head is probably referable to stimulation of the cerebellum. The curious fact is observed that, on closure of the current and during its flow, the individual tends to fall towards the side of the anode, whilst on opening the current he falls towards the kathode. Stronger currents produce nystagmus in addition, the direction of nystagmus during the current being towards the anode. Another variety of giddiness is that which results from rapid rotation of the body around its own axis, as in waltzing, or associated with sudden changes in our relation to space, as when on a swing or switchback. Such giddiness is probably due to rapid reversal of pressure in the endolymph when the direction of movement suddenly changes. The giddiness which some people experience on stepping unexpectedly from firm ground on to a somewhat boggy piece of moorland turf is probably due to sudden deficiency in the sensation of resistance from the skin of the soles and the muscles of the lower limbs. The vertigo which affects certain individuals when on "giddy" heights—so-called tower- or cliff-giddiness—is probably attributable largely to the loss of normal afferent impressions from the muscles of the head and eyes. Ordinarily we are accustomed, by movements of the head and eyes, to compare our position in space with that of surrounding objects at our own or a higher level, and when such objects are absent, vertigo results. Closing the eyes removes the symptom.

Diseases associated with Vertigo.—Many pathological intracranial conditions are associated with vertigo. Thus it occurs in head-injuries, slight or severe, and in cases of sudden alterations of intracranial circulation, whether in the form of anæmia or hyperæmia. The symptom is very common in women during the menopause. It is still more evident in cases of intracranial hæmorrhage or softening, and may be a premonitory symptom of various vascular lesions of the brain. Old people with atheromatous cerebral vessels often complain of giddiness, and if this be associated with headache, and especially if there be no evidence of labyrinthine affection, its significance should never be minimised. Vertigo also occurs in chronic as well as in acute increase of intracranial pressure; thus it is present in many cases of cerebral tumour, and is especially severe when the growth is in the region of the cerebellum or of its middle peduncle. In other diseases of the central nervous system, more especially in disseminated sclerosis, attacks of vertigo are common. *Epileptic vertigo* is a familiar variety, occurring either as the aura of a major attack or, it may be, constituting the chief evidence of the epileptic attack, in which the patient becomes suddenly giddy, falls to the ground, and may be unconscious. The writer has met with a case in which a young adult, after a single attack of "grand mal," was subject for several months to sudden attacks of momentary giddiness associated with overpowering fear, but without loss of consciousness. Vertigo is also met with in some cases of migraine, and in them, according to Dr. Liveing, it occurs after the visual phenomena and simultaneously with or following the headache. Sometimes vertigo replaces the attacks of migraine. Such cases are distinguished from the paroxysmal auditory vertigo about to be described, by the history of previous attacks of migraine and by the absence of tinnitus or deafness.

Certain poisons act upon the centres for equilibration. Amongst them the most familiar examples are alcohol and tobacco. Uræmic vertigo is to be included amongst the auto-intoxications, and probably so also are most cases of gastric vertigo, though some may be reflex, through stimulation of the vagus. *Gastric vertigo* is commoner in slight than in grave diseases of the stomach, and is associated with the ordinary symptoms of dyspepsia, such as pain and distension, perhaps vomiting. Sometimes the vertigo is suddenly relieved by gaseous eructation. But many so-called gastric cases on examination reveal some aural affection, so much so that Sir W. Gowers has questioned the existence of vertigo of purely gastric origin. Constipation is a frequent cause of giddiness, and it is a well-established fact that vertigo may sometimes be caused by intestinal parasites, disappearing at once when the latter are expelled.

Amongst other less common varieties may be mentioned nasal vertigo, which sometimes occurs in cases of recurring congestion of the turbinate bodies. Laryngeal vertigo, a somewhat doubtful variety, is said to occur in various laryngeal affections. Giddiness is often a symptom of neurasthenia and of hysteria, and in these affections it is frequently to be elicited by the slightest exciting cause; such, for example, is the probable explanation of the giddiness described as occurring on rectal examination or on compression of the testicle. A hereditary family form of giddiness has also been described.

Ocular Vertigo.—This variety, though somewhat rare, is quite definite. It is a form of giddiness occurring in cases of paralysis of any of the ocular muscles, and is associated with diplopia. The visual field being erroneously projected, the patient judges wrongly as to the relation of his body to objects seen. "Objects appear to be in certain positions where the patient's feet, as a matter of fact, fail to find them" (Hughlings Jackson). The giddiness in such cases is not due directly to the diplopia, for it persists when the sound eye is covered. (The condition can be imitated in health by closing one eye and displacing the other eye inwards by pressure with the finger, when if the subject tries to walk along a straight line the gait becomes very unsteady.) The explanation is to be found rather in the unusual effort on the part of the brain to turn the eyes in the direction of action of the paralysed muscle. Ocular vertigo, therefore, occurs only when the affected muscle is called into action. If the ocular palsy becomes permanent, the cerebral centres learn in time to neglect the error, and the giddiness then disappears.

Aural Vertigo.—Abnormalities of the auditory apparatus undoubtedly constitute by far the commonest cause of giddiness. Thus, for example, we may have conditions in the external auditory meatus producing irritation or obstruction with pressure on the tympanic membrane, as in accumulation of cerumen, foreign bodies in the meatus, or during ear-syringing, especially if a perforation of the drum be present. All those produce their effects by indirectly altering the pressure on the endolymph. Equally readily understood are the cases where the pathological process is in the middle ear, as in otitis media, obstruction of the Eustachian tube with diminished pressure, sneezing or blowing the nose, with consequent rise of pressure in the middle ear, also in paralysis of the stapedius or spasm of the tensor tympani muscle. Lastly, there is an important class of cases due to primary affection of the labyrinth itself without intermediation of the middle or outer ear. It is this particular variety to which Ménière called attention in 1861, and with which his name is commonly associated.

MÉNIÈRE'S DISEASE or LABYRINTHINE VERTIGO has three main groups of symptoms. *Firstly*—That due to affection of the semicircular canals, viz. giddiness with its associated motor phenomena of reeling and sometimes abnormal ocular movements, the sensory stimulus in this case being transmitted along the vestibular root of the auditory nerve to the auditory nuclei (of which Deiters' nucleus is one) in the floor of the fourth ventricle, and thence to the cerebellum. *Secondly*—Auditory phenomena, tinnitus and deafness, due to affection of the ordinary path for hearing, along the cochlear or truly auditory part of the auditory nerve to the nucleus accessorius, thence along the striæ acusticæ, and ascending in the lemniscus upwards to the brain without intermediation of the cerebellum. *Thirdly*—Associated bulbar or "vital" phenomena, explainable by affection of adjacent medullary centres, consisting in cardiac, vaso-motor and secretory signs in the form of pallor, prostration, and even syncope, cold clammy sweat, nausea, and vomiting.

The vertigo of Ménière's disease is paroxysmal, and comes on with such suddenness that the patient may fall to the ground as if struck down by an unseen hand. In other cases he reels, but has time to clutch at some neighbouring object to prevent himself from falling. He may either feel as if rotating himself or as if surrounding objects were whirling round him, or again as if the ground were sinking down under his feet. The giddiness lasts sometimes for hours; slighter attacks may pass off in a few minutes. It is increased by movement, and the slightest attempt to raise the head may induce vomiting. The direction to which the patient falls is usually forwards or towards one side, and this movement, whether real or apparent, is more commonly away from the side of the affected ear. In recurring attacks the direction of falling and of apparent movement of objects is usually the same. Not infrequently nystagmoid jerks of the eyes occur during the attack, and double vision has also been observed. Slight degrees of diplopia have been explained by Sir W. Gowers as possibly due to nystagmus of unequal degree in the two eyes, since no true ocular palsy exists. Momentary loss of consciousness sometimes, though rarely, occurs. The vertigo is frequently accompanied or followed by nausea and vomiting, lasting sometimes for hours. Headache is also commonly present. The patient is pale and his skin covered with a cold, clammy sweat. Together with the symptoms already mentioned, and simultaneous with them, there are characteristic auditory phenomena, generally a sudden loud noise. This has been compared by patients to the whistling of an engine, the roar of the sea, or the discharge of a gun. It is usually unilateral. At the same time, if attention be paid to the point, more usually later, it is discovered that there is deafness, more or less complete, in the affected ear, with diminution or loss of bone-conduction.

As the attack passes off, the tinnitus becomes less intense, the pallor and sweating cease, whilst the giddiness, nausea, and vomiting tend to continue, though less severe, for hours or days. A certain degree of deafness usually remains, but is rarely absolute.

Such symptoms, occurring with apoplectiform suddenness, constitute the typical picture of Ménière's disease. But frequently the paroxysms are much slighter and unassociated with nausea or vomiting, so that the patient may simply have sudden transient giddiness. But the attacks, whether slight or severe, tend to recur; rarely does a patient escape with a single attack. The intervals between them vary from days to months or years; they may gradually decrease in frequency, or may progressively increase until, with successive attacks, the deafness becomes absolute, when the vertigo generally ceases. Between the attacks the patient sometimes feels a slight persistent giddiness, but not invariably. In a certain number of cases the attack occurs at night when the patient lies down, so that he has to sit up for a time until it passes off. Or it may even occur during sleep and wake the patient up.

The pathological investigations recorded in Ménière's disease are somewhat scanty. In Ménière's original series of cases the symptoms came on suddenly in patients previously free from ear trouble. More usually, however, the phenomena occur in patients the subjects of previous ear affection of some sort, often in the middle ear. But it should be borne in mind that auditory vertigo, *per se*, is referable to changes in the semicircular canals of the inner ear. The lesion there is probably most commonly of inflammatory nature. In a few cases it has been a direct extension from adjacent middle-ear inflammation; more often it is the result of general constitutional disease, especially gout and syphilis. In other cases the slowly progressive character of the symptoms point rather to degenerative changes in the labyrinth, either senile or associated with atheroma of the vessels of the inner ear, as has been demonstrated in one case. Actual haemorrhage into the labyrinth, as described by Ménière, is undoubtedly rare, though it is the probable explanation of cases occurring in leukæmia or other bleeding diseases, also in some cases of chronic renal disease and in fractures in the base of the skull. Cases which have been recorded as supervening in tabes dorsalis are probably due to primary disease of the vestibular nerve.

The paroxysmal nature of the disease is more difficult to explain. Perhaps the labyrinthine disease causes a permanent instability of the equilibratory mechanism, so that it becomes acutely deranged by minimal superadded excitations, as, for example, by toxic, gastro-intestinal, or vaso-motor disturbances, or even by emotional excitement.

Four-fifths of the cases occur after the age of thirty, and the disease is twice as common in men as in women.

Diagnosis.—To those familiar with the phenomena of labyrinthine vertigo its diagnosis, as a rule, presents no difficulty. From ordinary epilepsy it is distinguished by the co-existence of vertigo, tinnitus, and deafness, and by the tendency for slight giddiness to persist between the attacks of severe vertigo. Loss of consciousness, which is the rule in epilepsy, is rare in labyrinthine vertigo. From cerebral hæmorrhage or softening the diagnosis is made by the presence of aural phenomena and the absence of signs of a focal brain lesion, either in the form of paralysis or affection of reflexes.

Paralysing Vertigo or Gerlier's disease is a curious affection which occurs among cowherds in certain Swiss cantons. The symptoms consist of sudden giddiness with ptosis, flaccid paresis of the muscles of the neck, legs, and sometimes of the hands, pain in the neck and occiput, and occasionally diplopia, transient amblyopia, difficulty in swallowing and in chewing. The affection has been attributed to toxic exhalations from the stalls, but its nature is obscure; possibly it is hysterical. The attacks occur several times a day, and between them the patient feels quite well. In any case the prognosis of the disease, which is known locally as "le tourniquet," is good, and the attacks after a time cease spontaneously.

The *treatment* of any individual case of vertigo depends upon the accurate diagnosis of its cause. Aural vertigo being by far the commonest form, it is the physician's duty in every case carefully to examine the ears. Vertigo dependent on cerebral hyperæmia is to be treated by appropriate depletory measures, whilst gastro-intestinal affections, if present, must be treated by careful regulation of diet, with suitable remedies to aid digestion. Intestinal parasites must be expelled. Even in cases of aural origin, attention to the digestive system must not be overlooked. Lack of food, according to Dr. Hughlings Jackson, is a factor in many cases of aural vertigo, and a patient may sometimes have an attack if he accidentally misses a meal. The beneficial effect of food in such cases is probably due to hyperæmia of the abdominal viscera, rendering the blood-supply to the rest of the body, including the brain, less abundant. Patients with Ménière's disease should therefore have a rather generous diet, and should have their meals at regular intervals. Where there is arterio-sclerosis, iodides should be exhibited. Gout and syphilis, if present, should be treated. Of all the drugs which benefit the giddiness, bromides, by their sedative action on the nerve centres, are the most efficacious. Any aural defect must of course, if possible, be remedied. Charcot recommended quinine in aural vertigo, others have recommended salicylates, both of these latter to be pushed until their physiological effects are produced upon the hearing. In neurasthenic cases, general measures should be employed for the constitutional condition, and may advantageously be combined with counter-irritation in the form of fly-blisters behind the ear.

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Vesiculae Seminales.

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ANATOMY OF THE SEMINAL VESICLES.—The seminal vesicles are two membranous receptacles, situated one on each side, beneath the base of the bladder, between it and the rectum, close to the angle formed by the bladder and the pelvic wall. When distended they form two long sacculated bodies, widened above and narrow below. Their length is usually about 50 mm., their greatest breadth about 18·5 mm., and their thickness about 10 mm., but they vary both in shape and size in different individuals on the two sides as do the testes, the right being usually the larger. Their upper obtuse extremities are separated widely from each other, but anteriorly they converge so as to approach the two vasa deferentia, which run forwards to the prostate between them. With the vasa deferentia thus interposed they occupy the two divergent sides of the triangular portion of the base of the bladder, which lies upon the rectum, and is bounded behind by the line of reflection of the peritoneum at the extremity of the recto-vesical pouch. The seminal vesicles themselves also rest upon the rectum, but are separated from it by a layer of recto-vesical fascia, which attaches them to the base of the bladder. The sacculated appearance of the seminal vesicles is owing to their peculiar formation. Each consists of a tube somewhat coiled and repeatedly doubled upon itself, and invested by dense fibrous tissue. When unrolled this tube is found to be from 4 to 6 inches long and about the width of a quill. Its upper extremity is closed, so that it forms a long *cul de sac*, but there are generally, if not always, several longer or shorter branches or diverticula connected with it, which also end by closed extremities. Inferiorly the seminal vesicle becomes straight and narrowed, and ends in its own duct—about half an inch in length—which unites (close to the base of the prostate) on its inner side at an acute angle with the narrow termination of the corresponding vas deferens to form a single canal, the common seminal or ejaculatory duct. The seminal vesicles receive branches from the inferior vesical and middle hæmorrhoidal arteries and veins. The nerves belong to the sympathetic system, and come from the hypogastric plexus. In structure the seminal vesicles resemble very closely the adjoining sacculated portions of the vasa deferentia. Besides an external investment connected with the recto-vesical fascia, and containing vessels of considerable size, lymphatics, and gangliated nervous cords, they have a muscular coat and a mucous membrane. The muscular layers are thin compared with those of the vas deferens, and consist of two layers,—an outer of longitudinal and an inner of circular fibres. A considerable amount of plain muscular tissue is found covering their posterior surfaces, and extending transversely so as to cover in the two vesicles. There are also longitudinal fibres traceable over the vesicle from those of the bladder.

In well-developed bodies this plain muscular tissue forms a distinct structure—ejaculator seminis—which is triangular in shape; its blunted apex being continuous with the prostate, where it is thickest. From here it passes backwards, widening and thinning as it proceeds behind the seminal vesicles and their intervening vasa deferentia, and is lost over the posterior surface of the bladder.

Fuller, of New York, in referring to this structure says: "The muscular fibres which compose the lateral lobes of the prostate have no defined posterior border, but extend backward, and become so blended with the musculo-fibrous tissue constituting the lower portion of the seminal vesicles, that it is impossible to say just where one ends and the other begins. If these muscular bands, which extend backwards from the prostate to the walls of the vesicles are observed carefully, it will be seen that these fibres are so arranged that, when a prostatic muscular contraction takes place, there would be exerted a strong pull in the lower half of the vesicle such as would give the whole seminal vesicle a strong squeeze."

The mucous membrane of the vesicles is traversed by very many fine rugæ, which form an alveolar structure resembling that seen in the gall-bladder, but deeper, and enclosing much finer meshes. The epithelium lining the vesicles is columnar, with a deeper layer of small polyhedral cells. It is probable that the seminal vesicles secrete a peculiar fluid, which is incorporated with the semen. The common seminal or ejaculatory ducts, two in number, are formed on each side by the junction of the narrowed ducts of the corresponding vas deferens and vesicula seminalis close to the base of the prostate gland. From this point they run forwards and downwards between the lateral prostatic lobes, and after a course of nearly an inch end in the floor of the prostatic urethra by two slit-like orifices placed in the verumontanum, one on each prominent margin of the prostatic utricle. Sometimes the ducts from either side unite together and open into the floor of the sinus pocularis. An ejaculatory duct is about three-quarters of an inch in length, and a seminal duct about half an inch, so that the urethral lining is little more than one inch distant from the lining of the vesicle, and it is not surprising, therefore, that inflammation so readily travels from one to the other.

Development.—The seminal vesicles are developed from that part of the lower portion of the Wolffian duct which goes to form the vas deferens. At the lower and outer part of this canal, towards the end of the fourth month of development, there appears a little button—a simple diverticulum of the deferent, which enlarges little by little, and is the rudiment of the seminal vesicle. At birth they form two distinct projections at the terminations of the deferent canals, more horizontal than vertical in their directions; their upper extremities not reaching the level of the ureters, and their surfaces being quite smooth. Their length is about 9 mm., and their breadth about 6 mm. Their cavity is relatively small to the thickness of the walls.

Until puberty the vesicles have only slowly and slightly enlarged. They are not more than 25 to 30 mm. long at the age of ten years, but as soon as the spermatic function is established, the activity of development which affects the testes, the penis, the larynx, and other organs affects equally the vesicles, which acquire very rapidly the volume they maintain during the whole genital life of the individual. Their infantile aspect may persist. The seminal vesicles have no analogue in the woman.

Contents and Function.—The normal vesicular fluid is white with a bluish white tinge like skimmed milk, and becomes quite viscid and sticky when exposed to the air. It is alkaline on reaction, with a peculiar heavy odour, and coagulates on heating. It is saline, and on standing numerous groups of crystals appear in it (Böttcher's crystals), consisting chiefly of phosphates. Besides spermatozoa the fluid contains a few leucocytes, numerous epithelial cells, slightly larger than leucocytes, a few round refractive cells, and considerable granular material.

The function of the vesicles is to store, temporarily, the testicular secretion, and also to provide means to preserve its vitality during that period. The semen is driven into the vesicles by a pumping action exerted upon it by the ampulla of Henle, and is expelled therefrom by a strong simultaneous contraction of the muscular fibres of the prostate and of the walls of each seminal vesicle.

The amount of testicular and vesicular fluid secreted in a given time varies greatly, and depends much on the mode of life and conditions of the individual. The amount of fluid ejaculated at a given instance varies much, depending, in a measure, on the frequency of the act. When the act is solitary and infrequent it averages from half to a drachm.

ABNORMALITIES.—No observations are yet recorded on the congenital deficiencies and irregularities of the seminal vesicles alone, but their condition in cases of retained or absent testis have been noted.

The seminal vesicles either unilaterally or bilaterally—according to whether one or both of the testes have failed to take up their positions in scrotum—show evidence of want of development, and appear as if they were almost absent in some instances. The vesicle on the side on which a testis has not descended is small, very saccular, and unfilled by semen.

It is in connection with the seminal vesicles that most of the pathological changes occur which cause disturbances in the sexual function; and the amount of disturbance in this function which these pathological processes cause, seems to depend largely at least on the extent to which they interfere with the act of ejaculation. The changes due to inflammation are the chief pathological factors in their consideration.

INFLAMMATION OF THE SEMINAL VESICLE.—*Spermatocystitis. Seminal Vesiculitis or Vesiculitis.*—Vesiculitis is the term applied to inflammation of the seminal vesicle, and may be acute, subacute, or chronic. The first is usually gonorrhœal, the second frequently simple, and the third either tuberculous or gonorrhœal. Inflammation depending on syphilis, gout, influenza, etc., probably occur also.

Acute Vesiculitis.—Acute vesiculitis is almost always excited by some affection of the membranous or prostatic urethra, usually by gonorrhœal, but occasionally by other forms of urethritis. The inflammation is the result of direct extension of the pre-existing inflammatory process, and is neither due to metastasis, sympathy, nor reflex congestion. Its analogies with acute epididymitis are striking, and are well worth attention. In the first place both affections are rarely primary, but are almost always secondary to urethral inflammation. They occur in the third or fourth week of a gonorrhœa. The inflammatory process in both affects also the surrounding connective tissue, and is characterised by a considerable amount of swelling, giving rise to the well-known ovoidal mass filling one-half of the scrotum in the one case, and to the diffused brawny swelling felt through the anterior wall of the rectum—mistaken for the acutely inflamed prostate—in the other. In epididymitis it is well known that it is not the testicle which swells, but the epididymal connective tissue; and in seminal vesiculitis it will be found, if a careful examination is made, that it is not the prostate which is swollen, but the vesicular or perivesicular tissue beyond. Suppuration in both cases is the exception, and resolution the rule.

When acute inflammation invades the seminal vesicle that organ becomes swollen to the feel, and approaches the size of a goose-egg. On touching it through the rectum, pain almost unbearable is experienced. The cavity of the sac may be distended with pus, and its walls, together with the perivesicular tissues, are swollen and œdematous. Sometimes this perivesicular inflammation is extensive enough to involve the neighbouring pelvic peritoneum, thus setting up a localised process which has been known to have eventually become general and destroy life. In a percentage of these cases the inflammation does not penetrate along the canal beyond the vesicle, but oftentimes it does extend so as to involve the epididymis, but rarely, if ever, reaches the testicle.

Vesiculitis ending in suppuration usually discharges itself by way of the ejaculatory ducts, but may form deep-seated abscesses in the pelvic tissues which may open into the rectum, perineum, urethra, or bladder.

Symptoms.—In acute seminal vesiculitis the symptoms presented are almost wholly those due directly to the inflammatory process. There is well-marked fever, often with shiverings or distinct rigors. In the early stages of the inflammation priapism and other evidences of excitement of the sexual centre are often present; but as the disease progresses these generally disappear. There is often a great throbbing pain in the perineum or rectum, increased if the patient sits or walks, and partially relieved if he lies down, especially on his abdomen or sides. Pain is often complained of in the sacro-iliac region. There is sometimes tenderness in the suprapubic area, corresponding to the side on which the vesicle is situated, and in very severe cases there may be a localised peritonitis at this part. The bladder functions are generally disturbed, especially during the early stages of the inflammation, the symptoms being frequent and painful micturition, together oftentimes with evidences of difficulty or retention. The painful symptoms increase as the bladder distends, and are felt most acutely at the end of the penis at the close of the act of micturition, after which a brief period of relief may follow. Defecation is frequently painful; the urethral discharge is lessened, and may disappear entirely. When the disease is on the increase, as indicated by the unabated continuance of fever, the urine voided is usually clear or nearly so. Then as the fever drops and the acute pain decreases, the urine may be found to be loaded with pus, caused by a natural discharge along the ejaculatory duct. This purulent condition of the urine continues for some time, until the sac is pretty well drained. Should the patient have in convalescence an involuntary emission as sometimes happens, the ejaculated mass is apt to be tinged more or less with blood, and the act is accompanied with a sensation of pain.

The diagnosis of acute seminal vesiculitis is made by rectal examination alone. The normal prostate can be distinctly marked out, and its limits defined, although it is usually somewhat tender and often a little swollen; but beyond the prostate, occupying the whole bladder base, is a hard convex resistant tender area, extending upwards beyond the reach of the examining finger. In its early stages swelling may be confined to a vesicle which can easily then be made out as a pyriform tumour, with its thick end upwards; but soon this vesicular characteristic becomes lost in the larger "perivesicular" inflammation which follows.

The diseases which simulate seminal vesiculitis, and are indeed usually mistaken for it, are the acute varieties of prostatitis and inflammation of the neck of the bladder. Fuller says that stricture, peritonitis, acute appendicitis, acute epididymitis, acute pyelitis, kidney colic, and acute inflammation appertaining to the rectum may also be mistaken for it.

Treatment.—Rest in bed, the patient lying flat on his back, is a most important requisite in the treatment of this condition. The testicle should be supported with a Baer's triangle (described in section on "DISEASES OF TESTIS") even although the epididymis is not tender. Large poultices or hot fomentations may be applied over the suprapubic or perineal areas, or ice may be similarly applied. Opiates should be administered to control the paroxysmal pain, and leeches to the perineum are often useful. Careful attention should be paid to the bowels, and the rectum kept empty by enemata. After the pus begins to discharge itself freely through the ejaculatory duct, poultices may be omitted. If, while the pus is discharging, urethral and vesical symptoms become annoying, balsamics may be given. Neither urethral injection nor instrumentation, nor vesicular stripping is allowable. The progress of the affection may be followed by occasional careful rectal examination. Resolution generally takes from three weeks to a month, during which time a patient should be confined to bed. In case suppuration should occur outside the vesicle, resulting in abscess formation, or an intravesicular abscess should fail to discharge itself per vias naturales, a perineal incision should be made after the manner described below, and drainage established.

Subacute and Chronic Vesiculitis.—These varieties of vesiculitis may be dealt with together. The former is usually of the nature of a simple inflammation, whilst the latter is most often due to gonorrhœa.

Simple inflammations such as may follow the passage of a catheter or sound along a healthy urethra, or may result from simple injuries, vesical calculus, or prostatic hypertrophy may extend from the urethra to the seminal vesicle.

The vesicle becomes moderately swollen, and its contents semi-purulent. Its walls, however, are but slightly involved, and it is very rare that the perivesicular tissues are invaded. The inflammatory process generally stops at the vesicle, but occasionally extends to the epididymis, setting up a light grade inflammation there which renders the part extremely sensitive, but which is not usually productive of much scrotal swelling.

Chronic vesiculitis is usually gonorrhœal. The common form of gonorrhœal invasion, and the one more to be dreaded owing to the lesion it leaves, is that which progresses slowly along the ejaculatory duct and into the vesicle, causing many functional disturbances, but comparatively little acute direct pain. Under the influence of this chronic gonorrhœal process the epithelium lining the part of the genital tract involved loses largely its columnar qualities, and becomes hard and pavement-like, and the subserous structures grow hard and sclerosed by interstitial proliferation. The lining membrane of the ejaculatory ducts may be altered by a chronic gonorrhœal process, but no stricture of their canals results. The interstitial changes oftentimes affect the tissue throughout the entire thickness of the vesicle wall, and is then prone to invade also the perivesicular connective tissues. When such is the case the surrounding tissues are first invaded by effusion of plastic lymph, which in extreme instances may fill up the post-prostate rectovesical space. These tissues then show to the feel the presence of hard œdema. This is a condition which the unskilled in the rectal feel almost invariably diagnose as prostatic hypertrophy. After a time this plastic lymph becomes organised into hard sclerous tissue. This hard sclerous tissue is much less bulky than the plastic effusion. Sometimes, generally in strumous subjects, gonorrhœal perivesiculitis, be it chronic or acute, may be suppurative. This chronic gonorrhœal process generally does not extend along the genital tract beyond the seminal vesicle. It may, however, involve the cord and epididymis. In such cases the cord is not apt to appear much if at all enlarged. The inflammation of the epididymis is less than in the acute gonorrhœal condition, while at the same time it is more severe than would ordinarily be expected from a simple inflammation.

Symptoms.— In subacute and chronic seminal vesiculitis, during periods of exacerbation, there may be painful sensations of a mild grade such as have just been described as associated with the acute form of the disease. In very many of these chronic forms of inflammation, however, the associated painful sensations are slight, and in a certain percentage of them pain is absent altogether. Oftentimes symptoms of pain and discomfort caused by the disease may be so reflected as to be associated in the patient's mind with other parts. Thus, painful sensations in one or both testes, scrotum, cord, along the urethra, end of penis, bladder, and kidney may be complained of. The rectum, coccyx, and small of the back may likewise be the seats of such pain. Instances are recorded where pain due to seminal vesiculitis has so closely simulated intestinal colic and sciatica as to mislead able practitioners. Numerous and varied bladder and urethral symptoms may be hereby caused. Thus micturition may be frequent, urgent, and painful, sometimes difficult; the urine escaping drop by drop. After the urinary act has been thus inhibited for several hours the spell may all of a sudden pass off and the urine be passed easily. If these cases are carefully watched it will often be found that the vesical symptoms, such as have been described, are most intense after sexual excitement. Then again, inflammatory symptoms may exist in connection with the urethra chiefly, less often with the bladder, which are dependent entirely on an associated seminal vesiculitis. In such cases an urethral discharge of vesicle pus will be found, there being no lesion in the urethra or bladder to account for the inflammatory evidences, and no amount of treatment directed toward the urethra and bladder will be found of any avail in curing the inflammatory evidences. As soon, however, as a cure of the vesiculitis may be effected, then these associated symptoms will be found to disappear permanently. Rarely the urethral discharge in such instances may be of such a severe grade as to be bloody. In some instances, through the agency of germ infection, the bladder (bacteriuria) may also become infected; when such is the case it will be found impossible to rid the bladder of the germ infection until after the focus of infection in the seminal vesicle has been eliminated. Another fairly common complaint in chronic seminal vesicular disease is that after straining at stool, specially over a hard bulky movement, there is apt to appear at the meatus a mass of glairy, sticky material.

In this class of affections, however, derangements of the sexual function are most marked, and furnish the most important group of symptoms. When the disease is not of very long standing the active evidences of irritation usually result in symptoms of sexual excitement, such as an undue amount of erections associated with an increase in sexual desire. Anything the least suggestive will be sufficient to excite the sexual centre. Involuntary emissions are in such conditions frequent, often occurring by day. These emissions are generally followed by a feeling of discomfort locally, and by depression generally. They may sometimes cause acute perineal pain. They lack force, and the amount of material ejaculated at a given instance is small. In some extreme instances there may be a feeling of ejaculation without any result, no fluid appearing at the meatus. If, in such cases, sexual intercourse be attempted, there is usually a premature ejaculation, accompanied sometimes by pain, and followed by failure of erection. In all such cases, however, whether there be premature failure or not, little satisfaction is obtainable from the act, the sexual craving still persisting undiminished by the sexual attempts. As the case becomes more chronic, feelings of sexual weakness grow more pronounced, and after a time there may be positive impotency. As the erections grow weaker and finally fail, so also do the sexual desire and craving, together with a cessation from emissions. In a small number of instances, potency may persist apparently unimpaired, although sexual desire and satisfaction may be lessened. In a few cases the sexual function remains undisturbed.

The character of the seminal fluid is altered in chronic seminal vesiculitis. It is often purulent and stained with blood. In other instances, where the inflammation is very quiescent, it may be thick and jellified. In most cases the spermatozoa which it may contain are dead on ejaculation. Neurotic sensations, some of them curious and indefinite, are often caused by seminal vesicular disease. Thus complaint is frequent, that the penis is shrivelled, cold, bloodless, and numb. The testes are often retracted and supposed to be atrophying. Bad feelings in the head and sometimes sharp headaches may occur after all. Sexual excitement, mental depression, and melancholy are common in aggravated and long-continued cases of this disease. The disposition may change, a placid person becoming irritable and quarrelsome.

The study of mental conditions dependent on seminal vesiculitis is very important, and a clear distinction should be made between such cases and those in which a psychological derangement is accompanied by sexual symptoms, there being no disease with the sexual apparatus.

Diagnosis of Subacute and Chronic Vesiculitis.—The symptoms and evidences derived from the digital feel per rectum are most important, not only in determining the grade and nature of the existing seminal vesiculitis, but also in differentially diagnosticating it from other affections. To be skilled in this feel the finger of the surgeon requires much education. To practise the rectal feel the bladder must be wholly or partially distended, and the patient assume a kneeling position—best upon the front of an ordinary chair, with his chest lying upon the top of the chair back. The forefinger of the surgeon is introduced as far as possible into the rectum, considerable force being used by the remaining closed portion of the hand to overcome the resistance of the perineal muscles when these structures are rigid. During this time a counter-pressure is maintained with the free hand over the pubes, in order to bring the seminal vesicles into easier reach of the forefinger. By so doing the various inflammatory conditions of the vesicles can be mapped out and appreciated. In case the finger detects evidences of vesicular disease, then Fuller's method of "stripping" the vesicle should be carried out, in order that a specimen of the contents of the sac may be obtained (see p. 343). As a result of this stripping the pathological contents of the sac are forced out along the ejaculatory duct into the prostatic urethra, from which part, if the expressed fluid be abundant, it flows along the urethra, and finally drops from the meatus. After the stripping the urine should be voided into a glass, and will show evidences of the expressed seminal material. It is a good plan, before the stripping, for the patient to pass a little urine in a glass, so that thus a natural specimen can be compared with the one containing the expressed seminal fluid. When the contents sac are largely purulent, the specimen of urine passed after the stripping will appear more or less cloudy, while that passed before the manipulation may be wholly clear or much less purulent. Where the vesiculitis is quiescent or very chronic there may be no purulent elements in the contents of the sac, in which cases the expressed material will appear in the urine as a partially transparent jelly-like mass, some of which may be globular and some cylindrical. Such cylinders are moulded in the ejaculatory duct. This jelly-like condition of the expressed seminal fluid lasts, however, but a few moments in the urine, since the acidity of that liquid quickly serves to dissolve it. There are many grades in the quality of the expressed seminal fluid, between the purulent and the jellified conditions. Blood may be mixed with the vesicular material, and may be readily recognised. If the bleeding is recent the colour is red; when not recent the tint is brownish. Degenerative changes in connection with pus may give a greenish colour; oftentimes also, especially after purulent conditions, shreds made up of vesicular epithelial desquamation occur among the expressed material. A microscopical examination should be made for spermatozoa. Sometimes in light forms of simple inflammation of the ejaculatory duct there will be seen in the urine passed after stripping the vesicle a transparent flake, which floats just under the surface of the urine.

The experienced digital rectal feel, together with the process of stripping the vesicles, enables one to diagnosticate seminal vesicle diseases from those of the prostate, bladder, kidney, appendix, rectum, etc. Thus also psychological conditions—functional impotence, hysteria, and sexual weakness due to general debility—can all be differentiated from seminal vesiculitis. Persistent urethral discharges or gleets, when simply symptomatic of a vesiculitis, are frequently mistaken for localised urethral disease, stricture, —posterior urethritis, granular urethritis, and not infrequently for chronic cystitis; and the mistake of diagnosing chronic vesiculitis for chronic pyelitis is not uncommon.

TREATMENT.—*Subacute and Chronic Vesiculitis.*—These conditions should be treated, according to Fuller, by "stripping" the diseased sacs at intervals of five days or a week. It is a safe rule always to begin gently with a new case, where the parts are usually very tender, and to get the patient accustomed to the manipulation before regular and complete strippings are attempted. If the stripping treatment is accomplishing the desired results, the parts should get gradually less and less tender, besides becoming more and more normal to the feel, and at the same time the subjective symptoms should show gradual improvement. Where the treatment has been employed too vigorously or too often, then the finger will detect evidences of fresh engorgement; there will be a reappearance of tenderness together with, oftentimes, an augmentation of subjective symptoms.

The duration of the treatment may be for weeks or months to a year or over. In simple non-gonorrhœal cases in youthful subjects, where the vesicular walls are atonic and no perivesicular inflammation exists, the cure is generally prompt, while in cases where the sac is bound down by extensive perivesicular inflammation or the individual is advanced in years, the relief from subjective symptoms may be slow, and a positive cure of the pathological process can never be said to occur. Still, even in the worst cases, time and attention will generally suffice to rid the patient of all local distress and inconvenience. During the active stage of treatment coitus should not be practised, and everything tending to produce sexual excitement should be avoided.

The stripping process effects a cure in seminal vesiculitis by aiding and strengthening the mechanism of ejaculation, and by promoting a re-absorption of inflammatory exudate. In all forms of seminal vesiculitis the mechanism of ejaculation is impaired, and, in some instances, it is rendered wholly ineffective. The stripping process, in large measure, accomplishes the results of ejaculation, while the muscles concerned in the act remain passive; and it does in many instances what the weakened mechanism has been unable to do—that is, it expels the jellified pathological fluid from the sac. The muscular apparatus by the passive exercise recovers its tone; it becomes better nourished, and the inflammatory adhesions which may have bound it down grow elastic and disappear.

During the local treatment the patient should live well, and take regular exercise—horseback riding and bicycling should be prohibited. In very chronic cases where progress towards recovery is slow, an entire rest from treatment for a month or so at a time is often of benefit.

The technique of stripping diseased vesicles is thus described by its originator (Dr. Eugene Fuller of New York):—

To accomplish the treatment, the patient, presenting himself with a full bladder, should, while standing with his knees straight, bend the body forward at right angles. Then the operator should introduce the fore-finger of one hand well into the rectum, the fist of the other hand exercising firm counter-pressure over the pubes. By these means the end of the forefinger will, in all ordinary cases, reach well beyond the posterior margin of the prostate. The bodies of the vesicles can thus be detected, one on each side beyond the posterior prostatic border (only the lower half of the body of the vesicle can be felt ordinarily by the finger, the rest being beyond reach). After the forefinger has been so introduced, firm pressure should be made with its tip on the body of the vesicle to be treated as far back as it is possible to reach. Then the finger tip, the pressure being maintained, should be slowly and firmly drawn forward along the line of the vesicle. The manœuvre is aided by the counter-pressure over the pubes with the free hand. This process may be repeated several times in connection with each vesicle. In this manner some of the vesicular contents, provided the sac be diseased and distended, can be pressed out along the ejaculatory duct, and into the prostatic sinus. After the manipulation the urine should be voided in order that the surgeon may see how much has been expressed. This treatment should be repeated not oftener than once in four days, and in most cases under active treatment as often as once a week. If it is done too frequently, or too severe pressure with the finger is employed, acute symptoms may be stirred up, which may leave the patient worse off, apparently, than before treatment was commenced, besides at times causing an acute epididymitis. The active stage of treatment lasts from four to six weeks in the most favourable cases, to eight or nine months, and possibly longer, in severe and chronic ones.

The stripping process is productive of good results not only by reason of its expressing pathological material from the cavity of the vesicle, but also by stimulating, in connection with the vesicle walls and surrounding tissues, a reabsorption of inflammatory congestions and exudations.

TUBERCULOUS VESICULITIS.—The seminal vesicles are occasionally the seat of primary tubercle, but in the majority of cases the disease is associated with similar affections of other parts of the genital organs, most frequently the testicle and prostate. Of thirty-six cases of disease of the seminal vesicles collected by Dreyer, in eighteen the affection was of a tuberculous nature, and of these cases one-half occurred in persons over forty years of age. It is often associated with tubercle in distant regions of the body, and is not infrequently secondary to gonorrhœal inflammations of the vesicle.

Primary Tuberculosis of the Seminal Vesicle.—In primary or acute tuberculosis of the seminal vesicle, the inflammation rarely confines itself to the sac and its walls, but shows a marked tendency to involve the perivesicular tissues. Such perivesicular inflammation may contain purulent foci, and may extend backward and involve the peritoneum. The disease often spreads along the cord to the epididymis.

In a subacute form there is a milder degree of inflammation, and fewer subjective symptoms. The walls of the seminal vesicle become moderately thickened, and little but local tenderness is revealed by palpation. Such cases may end a resolution, and rarely, unless aggravated by some exciting cause, extends beyond the seminal vesicle.

Secondary Tubercular Seminal Vesiculitis.—Secondary or chronic tubercular inflammation extending from the urinary tract represents a severe pathological disturbance. The chronic form, although not very painful, except when subjected to irritation, is always accompanied by subjective symptoms. In connection with the seminal vesicle, the inflammation sometimes shows a marked tendency to involve the perivesicular tissues, filling in the post-prostatic rectovesical space with a hard inflammatory extravasation, so that by the rectal feel it is impossible to define the posterior prostatic border. In severe cases this perivesical effusion may contain pus foci. This form of inflammation generally extends along the genital tract, beyond the vesicle to the cord and epididymis.

A certain number of cases here, as elsewhere, under favourable circumstances terminate in recovery either by resolution, by fibrosis, or by the disappearance of the tuberculous focus altogether. Sometimes the process comes to a standstill, softening areas calcify, and a calcareous nodule, which may remain quiescent, results. More often, however, the disease is continuously progressive, and abscesses form which may open into the bladder, the urethra, the peritoneum, the perineum, or the groin.

The symptoms of tuberculous vesiculitis are those of the other forms of inflammation, but the existence of hard nodules in different parts of the organ which are not very tender in pressure, is very suggestive of the tuberculous nature of the disease; and when these are associated with similar nodules in the prostate or epididymis, the diagnosis is certain. Recurrent urethral discharges are sometimes seen.

The treatment of tuberculous vesiculitis should be by general hygienic measures, but where the disease is primary, removal of the affected organ by operation is called for; and when the epididymis is also affected operative measures may still be adopted. "Stripping" should not be practised in tuberculous disease, except for purposes of diagnosis, and then only in the gentlest manner.

Little is known of the syphilitic affections of the seminal vesicles. G. Lewin once found the walls of the seminal vesicles indurated; in another case a cartilaginous induration of the walls was present to such a degree that there was hardly room for the head of a pin inside.

Dr. Fuller has seen a case of mumps where the seminal vesicle shared with the epididymis and testicle in the inflammatory process; and Comby, in a case of acute mump orchitis and epididymitis, was able by rectal examination to determine the existence of marked tenderness of the corresponding half of the prostate and of the seminal vesicle on this side.

CYSTS.—Cysts are occasionally found either due to localised distensions from the vesicle itself or from obstruction of the ejaculatory duct. Their diagnosis can be made by needle puncture, and they can easily be emptied by aspiration. Should more radical measures be called for, they may be excised by the method described below for the removal of the seminal vesicles.

Injuries.—Traumatisms in connection with the seminal vesicles are rare, owing to the protected position of the parts. They may be injured by a perforating wound involving the rectum and bladder, such as occurs occasionally when one is thrown against or sits upon a sharp body. They are also occasionally involved, one or both ejaculatory ducts being cut across or lacerated in surgical procedures, as in vesical puncture per rectum, for the relief of retention, in extensive prostatectomies, in median perineal sections, where the cut is very deep, and in attempts to draw a stone too large in size through a perineal wound. From such injuries inflammation may result.

Calculi.—Calculi of the seminal vesicles are rare. Guelliot says that these bodies are usually small, and bear a strong resemblance to prostatic calculi. They have a nucleus of spermatozoa, epithelium, and mucus, and are usually small and white. On analysis they are found to consist of seven parts of phosphate and lime and one of animal matter. Keyes removed a calculus from the ejaculatory duct by perineal section, and Fuller succeeded in discharging one the size of a grain of wheat by his own method of "stripping."

Malignant Disease of the Seminal Vesicle.—It is not uncommon for cancerous affections of the prostate, bladder, rectum, or testicle to extend to and involve the seminal vesicles. Primary cancer of the seminal vesicle, however, is apparently quite rare, although were digital rectal exploration of these organs more commonly and systematically practised, it probably would be found to be of much more frequent occurrence than the present statistics indicate. Guelliot, who has analysed fourteen cases, in which one or both seminal vesicles have been affected by cancer, finds but one in which the growth was distinctly primary in the seminal vesicle. Gay, of Boston, reports a case of primary cancer of the seminal vesicle in which he made an unsuccessful attempt to eradicate the disease by extirpating the organ.

Sarcoma of the seminal vesicle, either primary or secondary, is of very rare occurrence. Zahn reports the only case of primary sarcoma of this organ.

Malignant growths of this part disturb the sexual function, and, if at all extensive, interfere with urine drainage, and to a less extent with the functions of the lower bowel and rectum. They are also accompanied by pain more or less localised. The recital of clinical symptoms has been so meagre in the few cases reported, that an attempt at detail in this particular is impossible. Where disease is confined to the seminal vesicle, speedy extirpation of the organ is advisable. Rydygier's incision, which is a modification of Kraske's, is the method which should be employed, since that cut gives the operator the space necessary to make the removal most thorough and complete.

Operative Procedures.—The operative procedures which have been performed in connection with the vesicles are (1) aspiration; (2) incision and drainage; and (3) extirpation.

Aspiration is only applicable to certain cases of non-suppurative distension, and may thus be aseptically performed. A long, stout needle is entered about an inch in front of the anus, and a little to one or other side of the middle line, and is pushed on through the perineal tissues guided by a finger in the rectum until it enters the cavity of the distended sac. It has been chiefly employed as a means of diagnosis.

Incision and Drainage.—This operation is applicable to acute suppurations in and about a seminal vesicle, and is performed similarly to aspiration. A long narrow-bladed knife, with its edge directed outwards, is entered to one or other side of the middle line, an inch in front of the anus, and is guided by a finger in the rectum to the fluctuating area below. The blade of the instrument is gently rotated on its long axis to and fro, as it sinks into the tissues; when the abscess is "struck" the pus escapes along the side of the blade, and the knife may then be withdrawn, enlarging the opening in a direction obliquely downwards and outwards as it is withdrawn. A drainage tube may be inserted on a probe or with Lister's sinus forceps to the bottom of the wound.

Extirpation.—The perineum is shaved and prepared in the usual manner. A large gum elastic catheter is passed and retained in the urethra, and if the bladder is empty it should be filled with ten or twelve ounces of fluid. The patient is placed in lithotomy position, and having determined that the rectum is empty, a median incision is made from a point half an inch in front of the central tendon downwards to within half an inch of the anal margin. If the patient is stout and the perineum deep, the incision may be carried a quarter round the anus to either side, and about half an inch from it. The wound is deepened layer by layer, the rectum being pushed backwards, until the bulb, covered by its muscle, is seen at the front of the wound and the anterior fibres of the levator ani muscle looping up the prostate. These fibres must be divided mesially, and the under surface of the prostate clearly made out. The rectum must still further be repressed by means of long, deep retractors, and the special layer of fascia and muscle passing backwards from the base of the prostate over the vesicles divided laterally downwards and outwards in the direction of the vesicle. When the vesicle is clearly defined, it must be enucleated from its bed with the fingers, aided by a suitable blunt dissector if necessary. A finger introduced high into the rectum may be utilised to press the organ down into the wound, where it can be more easily grasped and drawn forward preparatory to being excised (Roux). Care must be taken not to damage the rectum in the early stages of the operation, nor the bladder or peritoneum during the enucleation of the vesicle. The cavity must be drained by iodoform gauze drainage, and the angles only of the outer wound closed by a suture. The wound gives rise to very little trouble, and heals rapidly if the whole disease has been cleanly removed. Nodules can be enucleated out of the prostate at the same time if necessary.

This is the plan I have several times followed in the removal of diseased vesicles, and have not felt the want of any other procedure; but other methods have been described and must be referred to.

Kraske's method.—An incision commences near the posterior superior spine of the ileum on the right side, and extends along the border of the sacrum and coccyx to the middle line of the perineum below. All tissues are divided down to the bone, and the coccyx and sacrum up to the third foramen are taken away. The deeper part of the operation proceeds in the lines of the one just detailed.

Rydygier modified Kraske's operation in the following manner. An incision commences just behind the posterior superior spine of the ileum, extends obliquely downwards, along, and half an inch from the border of the sacrum, and on to the coccyx to the middle line, along which it is continued towards the rectum as far as may be necessary. A transverse cut is then made inward across the sacrum just below the third sacral foramen, and the exposed bone divided across with chisel and mallet. The lower triangular flap is then raised without difficulty, and bent back, thus affording much exposure of the pelvic contents. After the completion of the operation the flap of bone and skin is replaced.

Von Dittel's method.—A catheter is tied in, so that the urethra may be easily appreciated, and shielded from injury in operating. For like reasons the rectum is stuffed out with gauze, the ends of which are left hanging out so that the whole can be easily removed. The patient is placed lying on his belly, with his legs hanging down. A cut is then made extending from the tip of the coccyx, down on the middle line almost to the rectum. It then deviates to the right or left as the case may be, just avoiding the rectum, making a half-moon-shaped curve around that opening, and terminating in the middle of the perineum. In completing the dissection the rectum is pushed inward and to one side. If more room is needed the coccyx can be removed, and the lower end of the incision, instead of terminating in the middle of the perineum, can be continued laterally and upward to the tubes ischii, thus combining the Zuckerkandl incision with that of von Dittel. This combination gives very free access to the rectovesical space.

Villeneuve claims to have removed a seminal vesicle through the inguinal canal, by laying this structure freely open in its entire length, and exerting upward traction in the cord (in a manner similar to that in the round ligament in Alexander's operation) until the vesicle is brought into view and excised. This operation is inapplicable where a vesicle is bound down by adhesions, as is usually the case.

Zuckerkandl.—The patient occupies the "lithotomy" position, and an English catheter of large calibre is introduced into the urethra. The operator sits in front of the patient, and guides the knife with his right hand, while the index finger of the left hand is introduced into the rectum, in order that in the progress of the deep dissection, the anterior wall of the rectum shall be avoided. A large perineal flap-incision is made, whose posterior extremity on either side extends to the tuberosities of the ischium, and whose anterior boundary lies in front of the rectum. After division of the skin, and the subcutaneous connective, the perineal septum is divided transversely, and blunt dissection is made between the rectum and the urethra upward toward the prostate. The detachment of the rectum is continued through a considerable extent, until the seminal vesicles and the base of the bladder become visible in displacement of the rectum towards the sacrum. The altered seminal vesicles are peeled out of their surroundings, dissected from the fundus of the bladder, and removed.

At the same time morbid collections in the prostate gland can be excised.

Resection and Extirpation of the Vas Deferens.—Resection of the vas deferens in its continuity has been performed in numerous cases. The vas is palpable through the skin, as a round firm strand, and it may thus be separated from the remaining structures of the spermatic cord. The cutaneous incision for the isolation of the vas deferens, 3 or 4 c.m. long, may be made either in front of the external inguinal ring, or at the neck of the scrotum. The structures forming the spermatic cord are forced out of the wound, and the incision is extended upwards as far as the level of the internal ring, the inguinal canal is laid open throughout, so that the vas deferens is exposed in its course through this canal, and is thus rendered accessible to surgical removal. The pelvic portion of the vas would be accessible by this means, only after extended detachment of the peritoneum, entailing injury of disproportionate degree. This portion of the duct is therefore to be reached by the perineal route, as already described, for removal of the seminal vesicles. In place of extirpation, divulsion of the vas deferens is recommended. The duct is isolated and exposed throughout its extent as far as possible, and by gradually increased traction until the vas gives way, about four-fifths of the duct can be removed.

Extirpation of the seminal vesicle has been practised in a number of occasions, generally for tubercular conditions. The result from such operations have not so far been very brilliant. Occasionally, however, the operation may be required. The Zuckerkandl, the von Dittel, and the Rydygier incisions, or combinations of these, represent the surgical methods to be employed.

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ARTERIES

Structure and Function.—Arteries possess three coats which are known as the tunica intima, tunica media, and tunica adventitia. The first of these consists of a pavement endothelium, with a very thin line of subendothelial connective tissue external to it. The tunica media, known also as the muscular coat, is composed of involuntary muscle fibres in the medium and smaller sized arteries; while in the aorta and its larger branches this coat is made up largely of elastic fibres. The tunica adventitia, or external coat, is composed of fibrous tissue, and in it are present the vasa vasorum, lymphatics, and nerves. Between the internal and middle coats there is often a lamina of elastic tissue known as the internal elastic lamina; and in some arteries a corresponding structure is present between the middle and external coats, and is named the external elastic lamina. The arteries are the channels along which the blood is carried from the heart and distributed to the different tissues and organs of the body. They constitute a system of elastic tubes, while at the same time their walls can contract and dilate under the influence of the nervous system, or of conditions present in the blood itself. This latter power they possess in virtue of the muscle tissue in their walls; and the condition of the muscle when in physiological action, is known as tone or tonicity,—the same term as is applied to voluntary muscle under like circumstances.

Variations in Tone or Tonicity.—Variations in tone are due to a number of causes. Mental emotion may lead, on the one hand, to contraction of arterioles and capillaries, and thus to pallor of the surface; while, on the other hand, other mental emotions may lead to relaxation of vessels, and a corresponding flushing or redness of the surface. Similar effects can be produced by drugs, by poisons, or toxines, either metallic, vegetable, or bacterial, and by the retained waste products of cell and tissue metabolism. When there is a lowering of tone the vessels dilate, and on the other hand, an increase of tone leads to contraction of the vessels; and to this latter condition the term hypertonus has been applied, while the contrary condition is known as relaxation or loss of tone. From this it is evident that the calibre of the same arteries must vary according to the influences acting upon them at different times, and this variation can be measured by finding the diameter of the vessel by means of Oliver's arteriometer.

Classification of Diseases of Arteries

Atheroma and endarteritis deformans.
Obliterative endarteritis (syphilitic and non-syphilitic).
Acute aortitis and acute arteritis (syphilitic).
Arteriosclerosis.
Calcification of middle coat.
Fatty degeneration of intima.

Atheroma and Endarteritis Deformans.—The changes which characterise this condition are met with in arteries which vary as much in size as the arch of the aorta and the central arteries of the brain. When the condition is present in an extreme degree in the large arteries, it leads to great alteration in the normal appearances, and to so much deformity that the name *endarteritis deformans* has long been applied to it. The use of this term must not be regarded as implying that the morbid changes differ in kind from those known as atheroma in smaller vessels, for they are as a matter of fact identical. The lesions which characterise both are the presence of localised areas of thickening of the tunica intima, with fatty or atheromatous degeneration of the thickened coat. The thickening of the intima consists of a hyperplasia of the subendothelial connective tissue. The atheromatous degeneration occurs first in the deeper part of this thickened intima, that is, in the part next the internal elastic lamina; but it may be scattered all through it, and it may be quite superficial and close to the lumen of the vessel. The atheromatous patches contain fatty and granular debris and fatty crystals. The patches tend to become infiltrated with calcareous salts. The atheromatous material may soften and form an *atheromatous cyst*, and the intima covering this may give way and allow the atheromatous material to escape into the circulation, an *atheromatous ulcer* remaining at the part. The condition may affect the arch of the aorta and its branches extensively; but no matter how extensive it be, it is always patchy. While atheroma is primarily an affection of the tunica intima, it leads to important changes in the tunica media. This coat becomes atrophied and attenuated, while the internal elastic lamina gets broken, and may entirely disappear at the seat of the atheroma. The atrophy implies weakening of the vessel wall, with the result that it yields before the pressure of the contained blood. This yielding leads to areas of dilatation, which may be so pronounced as to be sacculated (*see* "ANEURYSM"); while if the atheroma be extensive the entire arch of the aorta, or a considerable tract of a large vessel, may be dilated. Such an area is an *aneurismal dilatation.* Corresponding changes occur in arteries of all sizes, but in the small arteries the atheroma is either confined to, or is most marked, on one side of the vessel. This gives the affected portion of the vessel, when seen in transverse section, the classical "signet-ring" shape. As looked at from the outside the vessels, where affected, are opaque and greyish white in colour, more or less thickened, and, if infiltrated with lime salts, rigid.

Etiology.—Atheroma is said to begin as an inflammation, as a fatty degeneration, or as a mucoid degeneration. The essential characteristics are the thickening and fatty degeneration of the intima. The fatty or atheromatous change has of late been attributed to failure in the supply of nutriment to the thickened intima, the failure being attributed to the implication of the vasa vasorum. To this view, however, weighty objections can be found.

Effects of Atheroma.—As has been already mentioned, aneurism is one of the results of atheroma in the large arteries. Aneurism is not, however, confined to these, but also occurs in smaller arteries, especially those of the brain. In this region aneurisms may act as tumours, while by rupture they become a source of cerebral hæmorrhage. Atheroma has other important effects, more especially in the brain and heart. In these organs the nutrition of brain and of heart tissue respectively is impaired. This is due to the loss of elasticity in the arterial walls impairing the blood flow in the part, and to a diminution of the lumen at the affected points. The nutrition of these organs may be still further and seriously injured by the occurrence of thrombosis. In atheroma of the aorta the mouths of the coronary arteries may be almost occluded by the thickening of the surrounding intima. The relation between heart-power and atheroma of the cerebral vessels is of great clinical importance; on the one hand, strong cardiac action can be, and often is, the immediate cause of cerebral hæmorrhage; while, on the other hand, enfeeblement of cardiac action may so impair the nutrition of parts of the brain, as to produce motor and mental phenomena which are frequently mistaken for permanent injury. The impairment of nutrition is caused by the increased friction and consequent impediment to the blood-flow through the atheromatous vessels. Another and still more serious danger is the occurrence of thrombosis. This permanently cuts off the blood supply to portions of brain, and leads to softening, and to motor or other manifestations dependent upon the part of the brain involved. The clinician has thus to guide his patient between the two dangers of too strong or of too feeble cardiac action, and from the risk which follows each —hæmorrhage in the one case, thrombosis and softening in the other.

ENDARTERITIS OBLITERANS—SYPHILITIC AND NON-SYPHILITIC.—In endarteritis obliterans the essential characteristic is a progressive thickening of the tunica intima without atheromatous degeneration. The thickening is formed by a hyperplasia of the subendothelial connective tissue; in some cases the endothelium itself shares in the hyperplasia, and is therefore in part responsible for the thickening. The thickening is progressive, and leads first to diminution in the calibre of the affected part, and finally to complete occlusion of the vessel. These changes occur in limited areas in the course of the arteries, and do not, as a rule, affect extensive and continuous tracts of them. The thickening of the intima is fairly equal right round the affected part of the vessel, so that the condition presents this second anatomical point to distinguish it from atheroma. When this form of endarteritis occurs in the large and medium sized arteries of the brain it is probably without exception syphilitic: and it may be an acute process showing cellular infiltration of the tunica media and adventitia, as well as of the thickened intima.

A corresponding endarteritic thickening occurs in the small, nutrient arteries of the brain, but in some instances at least it differs anatomically in showing the tunica media to be atrophied or entirely destroyed. This is also probably syphilitic in origin.

While in the brain endarteritis obliterans may be taken as indicative of the causative factor named, it is, up to this time, not suggested that corresponding anatomical changes in the arteries in other organs have always this determining cause. In pulmonary cirrhosis, for example, obliterative endarteritis is found in the cirrhosed lung, while in the kidney the condition is frequently present. In the kidneys the changes in the arteries may, as in the small, nutrient arteries of the brain, be characterised by thickening of the tunica intima, associated with atrophy and even disappearance of the tunica media. In these organs the arterial changes may be primary, and lead to what is known as *renal arteriosclerotic atrophy;* while, on the other hand, similar changes occur in the arteries in the kidneys in primary interstitial nephritis. Both conditions give rise to forms of granular kidney.

Effects of Obliterative Endarteritis.—Wherever obliterative endarteritis occurs the local effect is interference with the blood supply. The brain is necessarily the organ in which the result of such an interference with blood supply gives rise to the most marked symptoms. First, there is diminished blood supply, finally there is complete failure. The local result is softening of the portion of brain tissue thus deprived of its nutrition. The clinical manifestations depend on the precise part of the brain involved. Here, more commonly than in atheroma, softening occurs, while hæmorrhage is rarer. In this condition it is also much more common to have local paresis or paralysis, and to have several such occurring in the same individual. The symptoms resemble those resulting from thrombosis in atheromatous cerebral vessels. A differential diagnosis depends upon the history, the age of the patient, and the condition of other arteries as the radials. The gradual diminution of arterial lumen with a correspondingly progressive diminution in blood supply is often indicated by a gradual loss of mental power or of other cerebral function.

Acute Aortitis.—Under this name is described a condition in the aorta and its large branches which is histologically identical with the obliterative endarteritis, which has been described in smaller arteries. It differs, however, from the analogous affection in these by not affecting continuously the entire circumference of the vessel. It is always a patchy condition, although the patches may be close to each other and the greater part of the aortic arch covered by them. The patches are raised above the level of the normal intima, they are grey in colour, and their edges are abrupt or sloping. Some points of fatty degeneration may be seen, but this does not seem to be any necessary step in the condition. On microscopic examination the patches in question are seen to owe their elevation to a thickening of the tunica intima corresponding to that already described in obliterative endarteritis. Along with the thickening of the intima there are areas of small-celled infiltration in it, and in the two other coats. Sometimes there is more or less distinct fibrosis in the tunica media. The condition is almost certainly syphilitic, and the analogue of obliterative endarteritis in smaller vessels. It has no necessary connection with atheroma, although, as has been said, there may be points of fatty degeneration in the thickened patches. The condition may lead to some yielding of the aorta and a measure of dilatation, but a much more important result is an interference with the blood supply to the myocardium when the mouths of the coronary arteries are involved in the process. The affection may not be extensive, and yet lead to this result by its presence at the part of the aorta from which these vessels originate.

Arteriosclerosis.—From the clinical standpoint this term is applied to all conditions characterised by either real or apparent thickening of arterial walls as that can be judged of by examining the radial arteries—the examination of other superficial arteries as the temporals being sometimes included. From the pathological standpoint it is applied to a number of distinct processes. By some it is applied to atheroma, by others to endarteritis, and by others to a thickening of arterial wall supposed to be due to fibrosis of the middle coat. Ziegler and others describe atheroma under arteriosclerosis, Huchard confines the term to sclerotic thickening of the tunica intima. Thoma promulgated a new view as to the etiological significance of the anatomical changes which requires special consideration, as his view has been accepted and promulgated by Mott in this country and by Osler in America. Thoma's view is as follows:—The elasticity of the arterial wall becomes reduced in a number of different conditions such as general diseases, acute and chronic infective diseases, long-continued disturbances of general nutrition, by many poisonous substances, and by functional overstraining of arteries from an increase in the heart's action. As a result the vessel dilates and its lumen is enlarged. In the dilated vessels the blood-stream is retarded, and this leads to a new formation of connective tissue in the tunica intima of the dilated vessels. The new-formed tissue renders the vessel wall more firm and less yielding,—a change in character which is recognised by the finger of the clinician during life. The explanation of these anatomical changes, according to Thoma, is that the thickening of the intima is to compensate for, or to counterbalance the increase in, the size of the lumen, and thus to restore the relation between the capacity of the blood-tube and its contained blood. By this means he thinks the rapidity of the blood-flow is re-established.

This theory is based on propositions which require consideration. The first of these is that arterial dilatation, that is, loss of arterial tone, occurs in a variety of circumstances. This can be accepted although the use of the word "elasticity" instead of "tone" has led to misunderstanding. In medicine the word "elasticity" does not convey Thoma's meaning. The second proposition is that the loss of tone and consequent dilatation leads to slowing of the blood-stream. The third is that the retardation leads to a thickening of the tunica intima, the thickening being compensatory, and having for its object the lessening of the lumen of the arteries. This third proposition is a pure assumption; mere slowing of arterial blood-stream cannot be accepted as determining a fibrous hyperplasia in the tunica intima. Were the presumption correct all persons with abnormally slow pulses would show this change in their arteries. The supposed object or purpose seems a too clumsy arrangement for the attainment of equilibrium in a disturbance of the circulation. In the kidneys this supposed compensatory process does not cease with the establishment of compensation, but goes on to complete occlusion of arteries, which it could hardly do were it so purposely designed as Thoma thinks.

The Proposed Use of the Word.—It has been already pointed out that the terms "atheroma" and "endarteritis deformans" are applied to definite changes in the arteries, the essential change being a special form of degeneration in the thickened intima. It is most unwise to extend these terms to thickenings of the intima which do not show these degenerative changes. Obliterative endarteritis, both syphilitic and non-syphilitic, show such thickening without atheromatous degeneration, and extensive endarteritis of large arteries may be present with but little atheromatous degeneration. Such changes the clinical pathologist ought not to term atheroma. There is a common idea that a thickened intima is only an early stage of atheroma, but this is quite inaccurate. Atheroma ought to be strictly confined to vessels whose thickened intima shows the special degeneration which has been so long recognised, and is so universally known. It is necessary to insist strongly on this point, as it clears the way for the consideration of the term "arteriosclerosis." This term etymologically signifies induration or hardening of the arterial wall, and it has been but comparatively recently introduced into English books. It is so used as to include atheroma; indeed it sometimes appears that the word is used as a mere synonym for atheroma, and as if all thickenings of arterial walls had atheromatous degeneration as their necessary or ordinary consequence. The inclusion of atheroma under a term merely indicating hardening might be of small importance if under the new term we had a satisfactory classification of all the various arterial changes characterised by hardening; but this is not supplied. The present writer holds that it is desirable to retain the term "atheroma" for the condition to which it has been so long applied; and this raises the question as to the condition to which the term "arteriosclerosis" may, without ambiguity, be applied. As already mentioned, the latter term is now used extensively in clinical medicine to indicate an arterial change recognised clinically by a real or apparent thickening of the radial arteries, to which is sometimes added the observation of a like condition in other readily accessible arteries of somewhat similar size. The writer has availed himself of considerable opportunities he has had of examining the condition of the arteries, after death, in persons who presented during life the clinical features to which the term "arteriosclerotic" was applicable. In these cases it was found that atheroma was no usual or necessary part of the changes present. It was found that the thickening, and, therefore, hardening, of the radial arteries was due to a thickening of both the tunica media and the tunica intima. The former was due mainly to a hypertrophy of the special cells of that coat, while the latter resulted from a hyperplasia of the subendothelial tissue. This thickening of the tunica intima is the condition to which Huchard, as representing the French school, applies the term arteriosclerosis, making it thus synonymous with endarteriolitis. It however differs from the obliterative endarteritis, to which reference has already been made in this article, in being a generalised condition. In obliterative endarteritis the thickening of the intima is essentially a localised and limited condition, and does not affect extensive tracts of vessels as arteriosclerosis is found to do. In the arteries at the base of the brain obliterative endarteritis causes swellings and thickenings which are markedly nodular, and even as prominent locally as aneurysm. In this implication of extensive and continuous tracts of vessels the process also differs from atheroma, which locally always occurs in patches, no matter how closely the patches may be placed to each other. The thickening of the intima is found to be present in arteries beyond the reach of investigation during life, so that the clinical inference drawn from the condition of the radials is fairly accurate. The change is present in the coronary, renal, and other arteries; while in the branches of the renal artery inside the kidney it may be present in so marked a degree as to completely occlude some of them; and in the nutrient arteries of the brain a corresponding degree of thickening may be present. Along with the change in the tunica intima there was also, as already stated, a thickening of the tunica media, which was mainly, if not entirely, a hypertrophy. This change has not been referred to by writers who use the term arteriosclerosis. Along with these changes in the arterial wall, the writer found marked diminution in the lumen of the radial arteries—the reverse of the condition which, according to Thoma's view, might be expected. While the condition of the tunica media and intima is such as has been described, it is important to note that in the branches of the renal artery within the kidney, and in the nutrient arteries of the brain, there may be no thickening of the tunica media, but that, on the contrary, this coat may be atrophied, and may even disappear, and the occluded vessel, when seen in transverse section, may appear as a hyaline or fibro-hyaline globe, with few or no nuclei. In this respect also the arterial changes differ wholly from atheroma: in atheroma the thickening of the intima does not lead directly to occlusion of the vessel, and atheroma does not occur in the arteries within the kidney. In the kidney, when an interlobular branch is occluded, all the Malpighian bodies, dependent for their blood supply on the occluded vessel, are rendered functionless; and following upon that, the tubules connected with them are rendered equally functionless. The consequent atrophy is known as arteriosclerotic atrophy, and gives rise to a *granular* kidney, which is commonly mistaken for the granular kidney of a primary interstitial nephritis.

It is necessary, in view of the position here taken up as to the application of the term arteriosclerosis, to state that atheroma, as well as arteriosclerosis, may be, and often is, present in the same person. Atheroma is so commonly present in some part of the arterial system that its presence along with arteriosclerosis need not surprise us. The point which requires to be enforced is this: that although patches of atheroma are found, it is not to be assumed that all thickened intima would ultimately undergo this degeneration. Such a view is totally inaccurate, for even in old people who have shown arteriosclerosis for years in their radial arteries, there may be no trace of atheromatous degeneration in them, and but little in the large arteries.

CALCIFICATION OF THE MIDDLE COAT OF ARTERIES.—This is a much rarer condition than calcareous infiltration following upon atheroma. It affects extensive tracts of arteries, converting them into tortuous, rigid, and brittle tubes. The calcareous matter which is deposited enters into chemical combination with the proteids of the tunica media. It can, however, be removed without destroying the coat, and without greatly altering its histological characters.

FATTY DEGENERATION OF THE TUNICA INTIMA.—This condition consists of a fatty degeneration of the endothelium, and is recognised by the occurrence of small, yellow, slightly-raised patches. They are common in the aorta and its large branches. It is probably always associated with a certain amount of thickening of the tunica intima. This, however, seems to be secondary to the fatty degeneration; at all events the degeneration is quite superficial.

THE CLINICAL RECOGNITION AND SIGNIFICANCE OF STRUCTURAL ARTERIAL CHANGES.—The main means by which the condition of the arterial system is judged is by examining the radial arteries. In them the points which are usually considered are thickening of the wall, tortuosity of course, and the presence of hard or calcareous segments. As has been already stated, it is a prevalent custom to call all thickenings of the radial artery "atheroma," and the objections to this loose use of the term need not be repeated. Atheroma is by no means as common in the radial arteries as is commonly supposed. When it is present they are tortuous and thickened, and the calcareous segments are readily felt. From this condition of the radials it is inferred that a like condition affects other arteries of like size; and of all these the coronary and the cerebral arteries are necessarily the most important. When, therefore, atheroma of the radials is associated with symptoms of angina pectoris, or of feeble heart without angina, the presumption is that the myocardium is suffering in its nutrition from a like condition of its coronary arteries; and this is in the main an accurate deduction. In addition to long-continued impoverishment of the heart muscle there is a further risk, namely, thrombosis of a branch or branches of the coronary, which gives rise to an infarction in the wall of the ventricle, a condition producing marked and prolonged cardiac disturbance.

In the brain atheroma may cause little or no disturbance of cerebral function. In old people it is probably a factor in the general lowering of mental and physical power, but it is often impossible to separate the deterioration of pure senility from that caused by faulty nutrition due to mechanical impediment. In this organ the main risks from atheroma are hæmorrhage and thrombosis, and of these the former is the greater. Reference has already been made to the great clinical importance of bearing in mind the relation in which the strength of the left ventricle stands to atheroma in the cerebral vessels. Conditions which temporarily increase the driving power of the heart and raise arterial pressure often lead to disastrous results; extra physical strain, mental emotion, a large meal, or too much alcohol, may all be the immediate cause of cerebral hæmorrhage. On the other hand, a feeble driving power on the part of the heart, commonly due to a degenerating and ill-nourished myocardium, often leads to repeated thrombosis in different regions of the brain, to consequent areas of softening, and to phenomena due to the part of the brain affected.

In addition to atheroma there occurs in the small nutrient arteries of the brain a progressive endarteritis such as has been already referred to as occurring both in this organ and in the kidneys as an accompaniment of arteriosclerosis. In it the tunica intima progressively thickens, and ultimately leads to occlusion of the vessel, and this without any atheromatous degeneration of the thickened part. This condition of the arteries is found in the brains of persons who have shown a slow but progressive mental impairment, and who ultimately develop either partial motor incapacity or such a degree of it as renders them unable to walk or stand or to use the hands for any useful purpose. The gradual onset and steady downward progress of such cases is readily explained by the progressive arterial changes which steadily lead to a lessening of blood supply to portions of the brain, until the supply is wholly cut off and there follows multiple areas of softening. The changes in the small arteries in these cases so closely correspond to syphilitic endarteritis that it seems to the writer open to question whether all these cases may not be due to syphilis.

A similar endarteritis occurs, as has been mentioned, in the branches of the renal artery inside the kidneys. This leads to areas of atrophy in these organs, and theoretically at least to a measure of incompetence; but these special organs seem to have a very wide margin—a statement borne out by the fact that one kidney can do the work usually done by two. It is unsafe, therefore, to lay much stress upon the question of incompetence.

In other organs a like endarteritis is said to occur and to interfere with special functions, but the organs mentioned are the most important.

THE RELATION OF ARTERIAL CHANGE TO CERTAIN DEFINITE NERVOUS DISEASES.—Recently Chalmers Watson and Ford Robertson have anew contended that the vascular changes which are present in tabes dorsalis and in the general paralysis of the insane are primary, and that the changes in the surrounding nerve tissue are secondary to and consequent upon them. The contention is that a toxin is present which acts upon the vessels in the special regions affected in those two diseases and leads to the vascular alteration. The toxin is regarded as having a special affinity for the regions implicated, or that the resisting power of the part is, from congenital or other causes, so lowered that the toxin acts upon it while not acting upon contiguous parts.

ARTERIAL HYPERTONUS.—This term has recently been applied by the present writer to a condition of artery characterised by tightening of it. Tone is the term commonly used to denote the degree of tonic contraction of arteries; and this tone may be diminished when the vessel is known as relaxed; it may, on the other hand, be excessive, and to this the writer has applied the term hypertonus. This hypertonus is characterised clinically by a thickening of the arterial wall and a diminution in its lumen. It can be recognised by the finger, and the difference in the diameter of the vessel can be measured by Oliver's arteriometer. The condition is frequently mistaken for arteriosclerosis. It is caused by the presence in the circulation of poisons or toxins, and as these are eliminated or counteracted the vessel relaxes. The condition occurs in persons even with diseased arteries, and is frequently the immediate cause of mental and motor phenomena in such persons, as can be proved by the phenomena passing off with the relaxation of the over-tightened-up arteries.

Treatment.—The treatment of the conditions which have been dealt with in this article may be considered from the two standpoints of prevention and of palliation.

From the former, namely prevention, the methods adopted will depend upon the view taken of the cause and nature of the arterial affection. It is an axiom in medicine that "a man is as old as his arteries," and it is recognised that from this standpoint many men show premature senility. The causes of premature arterial changes are not so generally understood, and whenever a change is of such slow development as it is in the conditions under consideration, there is a wide margin for difference of view. The first proposition which may be laid down is that the constitution or chemical composition of the blood exercises an important influence on the vessel wall and on the circulation through the vessels. Illustration of this is seen in the tension of the arterial wall in nephritis; the vascular condition being the result of the retention of waste products of metabolism in the blood. An analogous condition of vessel wall is often present in persons who suffer from chronic constipation, and during an attack of so-called "biliousness" in others. The conditions which determine arterial tension need not be enumerated, for the essential element in all is the presence of substances which act as toxins, and whose primary action is to cause constriction of blood-channels. The irritation and constriction lead to capillary fibrosis in the kidney, and in the arterioles and smaller arteries to a hypertrophy of the muscle coat and a fibrous hyperplasia of the intima. The amount and the character of the poison must vary widely, and so the length of time covered by the development of marked arterial change must proportionately vary. This leads to the second proposition, namely, that diet must be an outstanding factor in determining the vito-chemical composition of the blood. To diet may be added malt and spirituous liquors of all kinds. This is not the place to consider in detail the problems here suggested, but a general proposition may be safely formulated, and it is this, that if the intake of food or of such liquids as have been referred to is greater than can be promptly and efficiently dealt with in the primary and secondary digestion of the individual, the vessels feel the strain, and if this be continued or frequently repeated structural changes follow. The food elements which are generally accepted as producing the most deleterious substances belong to the nitrogenous or proteid group, so that whenever a tendency to arterial thickening is recognised, the supply of such food is to be reduced to a physiological minimum. The precise quantity has to be determined for each individual. This again is influenced by certain constitutional tendencies, as the rheumatic and gouty dyscrasia. There can be little doubt that premature arterial change occurs in families, but we take it that it is not the tendency to arterial change which is inherited, but rather a want of vigour of primary or secondary digestion, including the various excretory processes. The present writer has been long convinced that common forms of indigestion and constipation are the frequent cause of premature arterial changes. It thus becomes a matter of prime importance so to direct our patients that these factors may be reduced to a minimum. Diet, exercise, thorough bowel evacuation, and the condition of the skin, call for regulation as soon as the physician is given the opportunity of recognising the beginnings of change. If prompt action is desirable, the medicinal means at our disposal are mercurial laxatives to empty the bowel, while alkalies and iodide of potassium are often beneficial. Where arterial changes are already pronounced much may be done to arrest their progress, although the vessels cannot be restored to a normal condition. This can be effected by the same line of treatment; and it is sometimes surprising to find how much of the thickening of arteries is not due to structural alteration, but to the condition which has been described here as hypertonus. When this hypertonus is marked or is suspected, the use of the nitrites is followed by very marked improvement; iodide of potassium is also useful for this purpose, and we have also had good results from belladonna or its alkaloid.

Vice.

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VICE—SOME MEDICAL ASPECTS OF

THE term under which we have decided to write this article is probably not the best that might have been chosen, for it carries with it too much ethical import, and our first step must be to repudiate the moral imputation which the word vice conveys. There is no need for us to attempt philosophical accuracy, much less to aim at a contribution to ethics. Yet there is some resemblance between the view which the wise physician must take of certain practices to which some of his patients are addicted, and that with which the pastor or the teacher regards sin. From a moralist's point of view, vice must have a negative definition as a failure to achieve virtue, and so, to the physician, certain practices must appear as a failure to achieve the normal. For our purpose it is sufficient to define vice as a voluntary neglect or abuse of normal functions. We have to consider what the habits and actions are which interfere with health; and, in every relation of the organism, these may be considered as acts of neglect or as acts of abuse. For instance, it is vicious to neglect one's teeth, and it is vicious to chew tobacco; to take no exercise, and to "scorch" on wheels; to decline to eat, to eat too much, and to eat rubbish; not to make love, to make too much, and to make it in the wrong way.

At the outset we are confronted with the difficulty of determining what is too much or too little of anything, because we cannot ever expect to agree as to what is just enough even of a good thing; and still more difficult is it to agree as to what those things are which, in the vague phrase of some, are "harmless in themselves." Every case must be a law unto itself in the simple and physiological sense that anything is good which promotes the fitness of the whole organism, and anything bad which detracts from it. That at once debars us from social considerations, and sets aside the whole problem of motive. Many things which are good for the organism must, at least at times, be denied for the sake of society; and many things which are bad for the organism men and women pursue out of a desire to benefit their fellows. It is enough to suggest these and a host of other considerations which we propose to ignore, to amplify the confession that this is anything but a contribution to ethics. We propose to discuss baneful actions simply as such.

And when we try to discover what is good for the organism we come face to face at once with the question of what the organism is for. And we had best assume that the organism does not exist for its own pleasure or satisfaction, or for the approbation of any critic; or at least that it is not judicious for physicians to admit any such doctrine as a sober truth. The organism is for work; and it is our business to make it as efficient a mechanism as possible—fit to evolve the utmost energy it may, and for as long as possible. Vices then are acts and habits which depreciate the organism as a working machine.

Yet we have now no simpler a conception of the problem before us, but have only shifted the difficulty to another side of it. For instance, the duration of the organism's efficiency is a moot point; for one must choose between premature cessation of usefulness and superannuation; we must decide whether we shall encourage a short life at full pressure, or a long life of mediocrity. Here again we must have regard only to utility, and ignore the claim which even earnest workers advance to survive their usefulness, enjoy a senile leisure, and earn a respectable epitaph. Others, no wiser, would urge youth onward precipitately to a middle life of distinction, crowded and hurried with an excess of effort, and would regard with complacency an early death or even deliberate suicide. We can only repeat that every case must be a law unto itself. Each life should achieve its best possibilities, and should not be curtailed by excess of early effort; and it must be a matter of opinion how such an ideal is to be furthered. Yet it seems a wise maxim to enjoin, in conformity to our point of view, that no mode of life is justifiable, however brilliant its rewards and however full of zest, which depletes more than it replenishes the organism. For we must recognise that there is a normal limit of durability in all the organs of the body, and excessive wear and tear must be considered vicious.

As we consider this subject it becomes more and more clear that the practical problem in most cases is to ensure the proper subordination of the various systems and functions to the whole organism. It is nerve-work after all that counts; the evolution of our race has been towards a mode of activity whereby we project our personality upon the world by art and handicraft, by brain and nerves, which convey, in words and in deeds, the return which each man makes to the world in which he finds a living. The organism then is a hierarchy, of which the nervous system is the head and centre, not only for what we call brain-work, but for all effort such as constitutes skilled and unskilled labour, and also domestic activities. Each organ and system therefore must be developed and yet held in check, so that it may make its greatest possible contribution to the nervous system—to quicken the mind so as to promote its capacity for perceiving, thinking, and doing; and the difficulty must always be to determine when the indulgence of any one part of the organism, say the palate, becomes disproportionate, and takes from the whole man more than it gives. In considering that difficulty we should bear in mind two different kinds of value which attach to many activities. One of these is the nutritive value, as when one eats and feeds the blood, or walks abroad and refreshes it; the other is the dynamical value, as when a meal "gladdens the heart," or a noble prospect stirs the imagination. Although these two may be described in common terms, they have essential differences, one of which is that the blood system is the vehicle of nutritive values and the nervous system the chief vehicle of the dynamical; and there are probably characteristic differences in the chemistry and in other aspects of these two kinds of processes. It is the latter, the dynamical, utility which we are most apt to depreciate, especially if we share the view of the moralist, who regards all men and most women as of the same nature, and demands from everyone the same virtues and the same degree of each virtue. The physician, however, must recognise constitutional differences in his patients—not only for the purpose of nutrition, but also as factors in determining character and conduct. Probably the only physiology of mind which will enlighten us will, if it ever comes to be written, treat of the subject from this point of view; will describe the brain as a congregate of all the bodily functions as well as of the mental; and will show how it develops in relation to visceral and systemic and special sense stimulation, and how, utilising the forces of nutrition, it translates these energies into projective or practical activities. And in such a description there must be constant reference to the personal equation, to the fact that every organism is peculiar, inasmuch as the proportions of its several activities vary from those of all its fellows.

This much it has been necessary to say in a general and preliminary manner, for it is clear that an article such as this can only suggest a few aspects of so vast a subject, and leave the reader to work them out in individual cases. And though convention demands that, when we descend to the particular, we must discuss only a few flagrant kinds of misconduct, it is clear that mankind suffers far more from errors of omission which most people never dream of regarding as vice. That is the reason why we should focus our attention upon neglect of every function as a vice, and not confine ourselves to the idea of the abuse of function. No greater service could be rendered than to suggest to the practitioner how much the ordinary man loses by simple neglect of the possibilities of his nature. If a man has an eye for colour, he robs himself of an important source of energy if he does not satisfy it; a refined palate, an ear for music, a delicate touch, an aptitude for construction, a capacity for sports, and every other gift of the body that we can think of, all have a contribution to make to the organism which should be duly collected. And the same is true of our mental constitution. It is pitiful to think what scant consideration is given to the development of the endowments of the intelligence, with what complacence men and women who are most censorious concerning sins of the flesh pass over their own and their neighbour's mental indolence, and how carefully our schools cram information into young brains that are not taught even the elements of mental skill. And the whole organism suffers for lack of the appropriate zest. A man who neglects his gift for logic, for mathematics, for imagination and invention, or any other, not only loses the kindred result, the idea or project, which he might have reaped, but misses also the general inspiration derived from such exercises; for a prudent use of the mind's parts has the greatest of all values of that kind which we have called dynamical.

In pursuit of this physiological view of our subject it would be right that we should consider every function of the body and observe how its neglect or abuse reacted upon the whole organism and especially upon the nervous system, both as regards nutritive and dynamical values; then a second and larger volume should be devoted to a similar treatment of vices of the mind. But it is enough to suggest that course of study, and we must content ourselves with a few illustrative items. Other aspects we must also omit—etiology, for instance, which in every case is a relation between constitutional endowment and experience; pathology, which must refer to the secondary effects of vice, and becomes the pathology of the diseases which it has occasioned; and therapeutics, which can only be an elaboration of very elementary and often impossible advice. Nor shall we append a bibliography, which must needs include more that is misleading and uninformed and prurient than what is wise and appropriate.

THE ALIMENTARY SYSTEM

Vices of the palate alone would suffice for a topic which, if exhaustively discussed, would occupy many pages, and we must restrict our attention to a few points. One of these, and an important one, is the mistake of *childish eating,* a phrase which may serve to point the moral for the elderly, while it directs attention specially to the errors of youth. For it is beyond doubt that the great majority of children of the middle and upper classes are overfed. Indeed, it is ludicrous to remark how complacently parents look on while their children obviously dilate their stomachs. The habit is one to which young people are prone because they can only conceive of the immediate value of food and drink; that is, they fill themselves for the sake of the immediate satisfaction which follows. It is in part an over-indulgence of the palate, but the more important factor is probably a mechanical one. The child is happy when he swells with food, unless a wise nature sends griping to spoil the pleasure of it; and he becomes so used to a degree of abdominal distension that he is not happy without it. This question of quantity is as important as that of quality in diet. The chocolate and candy vice is of course a stupid error; but, on the whole, the food of the better classes is not bad if only they would take a good deal less of it. For, if you let a careless boy of nine or ten take his will of a tempting meal, he will put as much into his stomach as would fill a football. Parents are therefore well advised who appreciate the capacity of a normal stomach; and when we are consulted about children who are not gaining enough weight, or whose complexion is unsatisfactory so that, as the old saying goes, they "put their food into a bad skin," improvement will almost certainly follow if we prescribe only four meals daily, each of which can be contained in a breakfast cup. That lays upon the parent, and suggests to the child, the duty of having regard to the nutritive value of each meal; and small boys, who dislike the cure, will find some relief in a tightening of the waistband until the involution of their stomachs and abdominal walls is complete.

That suggests the interesting reflection that perhaps the crusade against tight-lacing may explain why we now see fewer "starving girls" than formerly. Only rarely, in these days when athletics are in vogue, do we meet with the misguided young woman who is too tired of life, or too pious, or too genteel to enjoy her lunch. There is a type of woman, however, often spirited and surprisingly energetic, gay and charming in society, but in her private moments pale and tired, nervous, peevish, and depressed, who cannot and will not eat a wholesome meal. Good food and healthy exercise are her aversions; but she counts upon her tea in bed each morning, and when she reclines upon the lawn, or in her boudoir of an afternoon; savouries have a great attraction for her, liqueurs, dainty confections and cigarettes; and her unfortunate physician is periodically called upon to sanction phenacetin or antipyrin for a complication of nerves, dyspepsia, and menstrual headaches. That kind of vice must be put down with a strong hand in girlhood; and when it has become established, washing out of the stomach and the enforcement of the elementary rules of hygiene will either effect a remedy or rid the physician of an unsatisfactory patient.

This brings us to the very difficult subject, the vice of *drinking*, concerning which it is almost impossible to speak wisely. One aspect of it, not generally understood and appreciated, we may first consider, because it is important in all serious vices. It may be described as the reaction of the conscience, an interesting physiological conception. Very often, perhaps usually, drinking dulls the conscience early in a career of drunkenness; but a great many men and women who drink too much, and who know they drink too much, yet who are not to be called drunkards, illustrate this reaction. For convenience we may use the term conscience in its loose and popular sense and take it to embrace not only a sense of right and wrong but also the sense of what is proper and expedient. Now even an elementary conception of the physiology of mind enables us to understand that the mechanisms of this great group of functions must be widespread and strong, that is, capable of intense and far-reaching activity. The group is of course one which subserves emotion and sentiment; and in the evolution of the human mind, from the beginning of social life onwards, the instinct for approbation has been about the most important of the springs of conduct. In the life of the individual the same importance manifestly attaches to these functions, as when the child refers every question of conduct to the criterion of a parent's praise or blame, and as when the man develops a sense of the approval or disapproval of God. What the nature of this fabric may be we can only conjecture; it is enough for us to recognise that there is such a mode of activity which obtains as an accessory to nearly every self-conscious act. And the important fact is that when the reaction of this group of functions is opposed to, instead of being in harmony with, conduct a great disability is imposed upon the whole mind. As yet, we are not in a position to explain how one set of cerebral mechanisms inhibits or impedes another, and there may be no direct opposition of forces, but this much is clear, that when a certain act or habit fails to achieve the concurrent activity of so important a function, there must be a great loss of force, a much weaker production than would otherwise have resulted. Psychology, however, suggests something like actual conflict and corresponding waste of power; no mind can be quite efficient which is dogged by the consciousness that its course of action is unworthy. And, in these days when the fashion is to interpret all pathology in the crude terms of nutritive values always conceived of as pertaining to the blood-stream, it is needful for us to emphasise this other aspect of the problem. Worry certainly is as potent in the production of cerebral exhaustion as any other single factor that we can name, and it is our business to find some physiological conception for it. For this reaction of the conscience is often excessive and becomes in itself a vice; in women especially self-consciousness is often exaggerated, and the mind suffers from a too frequent and undue criticism of its performances. Many people suffer in this respect in regard to drinking.

It is useful to discern this type, which we may call the timid drinker, for it is necessary to deal with him in a manner quite different from our management of the obdurate drunkard. And, to begin with, honesty and a frank recognition of the truth about drinking is urgently called for. It is time, for instance, that the untruthfulness of the teetotal fanatic should be exposed, and the fact brought home to him that he has been a prime influence in retarding both private morality and legislative progress. The total abstinence injunction is obeyed, for the most part, by persons who have the least need of it; it has admittedly saved many reckless and confirmed drunkards; but it has also hastened the ruin of many young people who, tempted to depart from the custom of their parents, have been impelled to do their drinking alone or in undesirable company, and have added shame and fear to their weakness. Another result of the disrepute in which all drinking is regarded in certain communities is a failure to appreciate good and bad stuff. Taken all over, the drinking practices of the people are very gross and crude; a wise parent will be at some pains to educate both his own palate and his sons', and will encourage a taste for the lighter and purer liquors; and even some who habitually exceed are improved by more cultured selection of their drink. And the time at which people drink is of importance in this same connection, for the habit of drinking largely at meals is a pernicious tradition; much of the ill-effect of alcohol is due to incomplete digestion; and it is therefore probably wise to have a large and dilute drink not less than half an hour before dinner, and let that meal be as dry as possible.

The suggestion that people should be taught how to get the utmost value out of both food and drink is part of a general increase of attention to physical culture, which is having a marked influence upon the practices of the rising generation. For the rest, there is not much to be said about excessive drinking that has not been too often said already. We should be as careful, however, not to err on the side of leniency in our dealings with the obdurate drunkard, as to be not too severe on the timid patient. The latter will respond to peaceable and enlightened measures, and especially to the frank confidence of a friend. The thick-skinned sot requires coercion and intimidation. And that brings us to the everlasting demand that the law should deal boldly with these cases. Even short of compulsory detention in a Retreat, great good would be accomplished if, as has been suggested, powers were granted for proper authorities to farm the wages or salary or other income of the drunkard.

Drug Habits and Smoking.—Indulgence in narcotics is dealt with elsewhere, and upon all such practices there is nothing new to say. The whole problem simply demands courage and frankness, common sense and firmness. If, for example, it is true that cigarette-smoking among boys is greatly on the increase, and that it is very harmful, it should be easy to rapidly diminish it. Any practitioner of parts could easily stop such a habit in a boy who was not an imbecile by some plain speaking, and by putting him under the informal control of a strong companion. If, as is suggested, physical training is to become an important feature in our educational system, one of the effects will likely be to diminish smoking and other vices. This is a kind of question, however, in which exaggerated opinions are apt to come to the surface.

For drinking, for drug habits, and for other vices, it is surprising that so little good use has been made of the therapeutic voyage. Sea voyages, as a rule, are of a minus value for the vicious; but that is probably because the regime is not explicitly arranged to suit such cases. It would be an interesting and probably a valuable experiment if some one would organise a series of therapeutic voyages during which every passenger would undergo a course of systematic physical training, with an experienced physician to prescribe and a hard-hearted captain to enforce the discipline necessary in every case.

Constipation.—Neglect to evacuate the bowels is a very prevalent vice, especially in women. It is indeed surprising that there is not more widespread knowledge of the importance of the excretory functions; perhaps the majority of women in the poorer ranks, and a considerable number of the well-informed, believe that two or even less evacuations in the week are sufficient; and it would seem that many physicians are not much more enlightened. The reason is, that, in some cases, the system becomes habituated to the intestinal poisoning, and suffers only a slow and perhaps postponed injury. In such cases, however, improvement in general health is obvious if a daily and complete evacuation is achieved, though it is common for the patient to feel worse for a short period if the habit of constipation is suddenly broken and intestinal activity too suddenly induced.

THE NEURO-MUSCULAR SYSTEM

It is quite impossible to even suggest the various vices of nerve and muscle which the physician may have to deal with. It may be useful, however, if we would induce a patient in ill-health to make the most of himself, to repeat that abuses and neglects of nervous activities are both prevalent and important. Restlessness and excitability in all its forms—from the habit spasms of the choreiform to the garrulity of the illiterate and the anxious worrying of the too self-conscious—are amenable to common-sense treatment, and will repay it. But the neglect of the muscular system is a more frequent and an important fact in present-day life. Our men are perhaps busy enough in working hours, but, in hours of leisure, indolence is the rule. It is astonishing how seldom one meets a patient who can do anything at all except the business by which he earns a living, or who has any interests and tastes which stir his intelligence. And young women suffer still more in this respect. One of the most striking characteristics of their class is an over self-consciousness consequent upon a sense of uselessness. The amount of time and energy devoted to the learning of certain accomplishments which rarely have any tangible result is simple waste. The mind requires an outward effort, and something to show for it. There are few activities which yield so much zest in life as those in which there is something to be seen actually growing before one's eyes. The fashion which at present encourages young people to develop their muscles severally and assiduously, depends to some extent upon this pleasure which we normally have in a palpable demonstration that virtue is rewarded. But it is difficult to understand why the same energy should not be devoted to more useful pursuits. Gardening is perhaps the ideal industry, in that it gives exercise to great masses of muscle, encourages a love of open air, promotes hardihood, and forms a contact for the mind with primitive and natural forces. But there are endless forms of handicraft which are easy to learn yet persistently neglected, and which would repay much culture. For one of the most useful and fertile elements in a human mind is the consciousness of skill and the stimulus which comes from the mere success of making something. Our race has developed along lines in which the formative or constructive activities were of the utmost importance; the exigencies of city life have led us away from them; and they are wise who, even under great difficulty, reach back to them. This is a therapeutic which physicians, as a rule, are much too slow to utilise. For patients who are subject to nervous ailments are invariably too self-conscious, at least in the early stages of their illness, and in many cases that stage would not be reached if men and women were seriously interested in projects other than personal.

THE SEXUAL SYSTEM

The physiological excuse for the tendency of civilised nations, and especially, perhaps, of the British, to make a fetish of chastity is to be found in the monopoly of the attention which sexual indulgence is apt to establish. The same is true of gambling and of gluttony, though not to so great an extent. For the sexual function is woven intimately into the whole nature, and its activities swamp and inhibit, or at least suborn, all else. Only a few men, and still fewer women, can make an art of loving and yet retain their interest in affairs. Love makes a fool of a man; to be enamoured is to neglect all but one aim; and to make a study of sexual practices of necessity debauches the mind. And this, be it observed, is especially true of illicit and perverted sexual vice, for then the mind is weakened and predisposed to calamity by the reaction of the conscience, focussed in a fear of discovery and disgrace.

In this connection it is well to dissociate ourselves from the purely spiritual aspect of the subject, and to have special regard to the physiology of emotion; for we have, in the psychology of sexual indulgence, a vivid example of the importance of cortical arrangements and their relations with visceral ganglia in determining diseased processes. The sexual mechanism, as has been observed, must be very widespread in its connections; from the organs of generation tracts, obviously capable of intense activity, reach inwards to the sensorium, and are presumably adapted both for the reflex activities which occasion trophic changes in various organs and vague systemic effects and also, probably by special fibres, for the direct stimulation of the cortical mechanisms, whose activities coincide with appropriate emotion. For this sexual function we must remember the unlimited avenues of stimulation from without as well as from within, from vision, hearing, smell, and touch; and, on the other side, the expressive or outward relations which are the characteristic effects and acts of this function, such as those which permit of interference with respiration and circulation, with vaso-motor functions, and even with gastric and renal activities, and the other more voluntary relations which become translated into ideas and purposes and acts. We are justified in assuming that, at least in some people, this mechanism is the most powerful—fit for the most intense activity and having the most widespread relations; while in others it would appear to be insignificant. And we cannot ignore the corresponding differences in the dynamic value of two such natures. For it is absurd to deny the importance of such a function in stimulating the whole organism, or its importance at other times in depleting it, and again, if it is at variance with what we call the conscience, the disturbance and instability which such a conflict occasions.

Apathy.—The first vice which we have to consider in relation to this group of functions is the feeling and practice, often due to constitutional defect, which finds expression in the view that virginity is of itself a good thing. It is almost unnecessary to say that women are more commonly defaulters in this respect than men. It may be hazarded that in every such case, when the apathy is genuine, there is a structural reason for it, most commonly perhaps in the cortex—a kind of sexual imbecility. In men it is commonly associated with cowardice and selfishness—a foolish bashfulness or an undue subservience to a false idea of modesty, and, very often, an exacting fear lest to share another's emotions should curtail the opportunities of other forms of self-indulgence.

But this vice of sexual neglect is commoner in women—so common indeed as to be alarming, for its prevalence bodes ill for the race, and it is moreover an important factor in many cases of conjugal infelicity. One even hears of women long married who do not seem to have ever experienced any great sexual awakening, though perhaps from a sense of duty they permit intercourse with the husband. In some instances it would appear that this function has never been reached, because it has been fenced off by constitutional barriers which prohibit any state of mind approaching to abandon, and which predispose to a constant watchfulness or determine an exaggerated idea of dignity. Such cases are probably hopeless unless the hidden potencies can be exploited by some ingenious and subtle suggestion which associates love-making with mystic ideas under circumstances likely to induce ecstatic feeling. Perhaps the majority of cases of feminine apathy, however, are occasioned by the aggressiveness of the husband, which creates in the wife a revulsion against a practice which would make her merely the instrument of an appetite which seems both senseless and beastly. In many instances, unless this adverse relationship is of long standing, a felicitous result follows when the husband learns to regard his wife's feelings before his own. In any case, apathy is not a state which the physician should ignore; for we must recognise how profound and beneficial an alterative effect sexual awakening induces, how married life promotes healthy metabolism if pregnancies are not too frequent, and how it enlarges and revives the mind. That effect, it is interesting to surmise, may depend in women partly upon the dynamic value of opening up the sexual tracts in the nervous system, and partly upon the quickening effect of germinal infusion upon the general metabolism.

Sexual Excess.—Sexual excess is probably not commoner than sexual neglect, though a perverted public opinion metes out to it a more ready condemnation. Its evil effects upon the organism are both obvious and manifold. We must specially bear in mind the claims which an excessive sexual indulgence makes upon the attention, how hard it is for the sexualist to do good work, and how likely he is to miss many of the most desirable intellectual and emotional interests; and also the probability that his health will be impaired and his disposition demoralised. Here, again, we have to note two types: one of them unashamed, and even careless of detection, and who consequently suffers less; the other, under the reaction of fear, apt to become furtive and morose.

Perhaps no form of vice illustrates better the maxim that every man must be a law unto himself. For it is clear that what is excess for one person may be of no bad effect upon another. Each case must determine to what extent the indulgence can be permitted, and at what point the whole constitution loses more than it gains by it. The gross evidences of such an injury would be sought for in the skin and in muscle and nerve—pallor, flushings and pimples, tremor and restlessness going on to loss of sleep, with perhaps the addition of perverted appetite for food and drink.

Nothing can be expected from a restatement of the appropriate treatment in such cases. Even if the physician detects signs of this vice in any of his patients he will probably not feel justified in interference. When the patient comes with a frank confession and a sincere desire for a reform of his habits, the battle is half won, and nearly every such case should have a successful termination. The management of such a patient is a mere matter of common sense. Above all, the patient's attention should be directed away from his habit, and not focussed upon it; that is, he must be encouraged to develop his spiritual and his physical nature to the highest pitch of fitness of which they are capable; and all the effort and enthusiasm that can be evoked should be explicitly directed to that end, with the least possible reference to the vice that makes the effort necessary. That is true of most habits. We must remember that vice is supremely interesting, and especially to the vicious; that every victim of a depraved habit has an "inverted gusto" in discussing it, even though it be in tears and with every token of repentance; that the best chance for every one is to keep his mind fixed upon, and order his life so as to achieve, the other activities which he has been neglecting; and if, after all, the vice persists, it is a great gain if the patient, notwithstanding his lapses, occupies his mind in his "lucid intervals" with things that are worthy and above reproach. To such an end wise companionship is almost indispensable. And for this and other vices we should remember the usefulness of the idea of postponement; that, while it is often impossible to persuade a patient to total abstinence, and very hard to get him to stick to a prescribed discipline, it is always useful, and appeals to his most manly instincts, to induce him to practise daily the trick of putting off and off the hour or the day of his indulgence. Many men are interested and even amused at testing their endurance, and have an added zest in expectation of the added pleasure which their postponement of it ensures, who could not be brought to even attempt total abstinence.

Sexual Perversions.—We may affirm, probably without fear of refutation, that the great majority of the boarding-schools in this country are infested with sexual vice. The evidence of masters, and especially head-masters, is of the least possible value in this connection. We must go for evidence to "old boys" who have reached years of discretion, and who have learned to regard their sexual organs as wholesomely as they regard their other members, yet who have no interest in boasting or other exaggeration. Any one who is in a position to acquire the facts, and who takes pains to probe the subject, can convince himself that there is hardly a boarding-school in the country which is not, at least at times, a hot-bed of sexual vice. For obvious reasons, it occurs in epidemics, for it is of necessity contagious. This applies even to masturbation; the self-taught masturbator is about as rare as the self-taught drinker, for it is characteristic of the vice that its victim has a strong desire to communicate it to his fellows. And so at times in large boarding-schools the state of affairs is not only very bad, but, at least among the boys, quite notorious, and a few ringleaders, even openly jealous of each other's conquests, renew their barely-concealed efforts to add to their train of followers.

In such epidemics there comes to be something like a cult of sexualism, and, if it were profitable to pursue the subject minutely, we should find many resemblances to the mystic rites of savage tribes. Not only do the boys vie with each other to discover new and attractive methods of sexual stimulation, but we hear also of the outcropping of the curious perverted instinct to inflict wounds upon themselves and upon each other; of the bestowal of, for them, princely gifts upon the objects of their affection, as upon a mistress; and even of the placing on a pedestal of some chosen child, perhaps more comely in appearance and in spirit than the rest, whom one of these leaders in vice will champion, and whose innocence he will protect with the most jealous care against both his own and his rivals' blandishments.

On the other hand, it is only fair to say that at times the spirit of those same schools may turn from such vices, and show a corresponding zest in observing a clean and wholesome life. It is also most necessary to point out that what has been said refers only to boarding-schools, and that apparently the day-schools of the country are very rarely infested.

The most difficult and perhaps the most important part of this problem is to determine to what extent such vices prevail among girls and women—difficult, because its investigation is one of insuperable delicacy in cases which it is most worth one's while to try to save; and important because it is next to impossible for a woman to persist in such practices with anything like an even mind. Many vicious men are comparatively happy, and live fairly cheerful and successful lives. Women cannot be so, partly because their sexual nerve-tracts are less detached than in men, more intimately and widely related to other functions, and partly because the conscience-reaction is almost invariably greater and more disastrous in women. It is enough to say that masturbation by women is much commoner than is generally suspected by physicians, and that it is probably our duty, in neurasthenic and allied cases which baffle us, to overcome the difficulty of determining whether this is or is not a factor in the case. The treatment is not more difficult than in men, but we must bear in mind this important difference, that, while many men may underestimate the evil effect of bad habits, a woman almost invariably exaggerates it, and one's attention in her case should be explicitly directed towards a more confident and unself-conscious state of mind.

Nothing is to be gained by a more elaborate study of perverted sexual practices. It may be admitted that the subject is an interesting one; but the interest of it does not seem to be wholly scientific. The most that can be done is to suggest that these evils are much commoner than is supposed, and that physicians should be alive to them, and talk the subject over not only with boys but with parents, many of whom are in a state of crass ignorance on the subject. And a word of warning is necessary in dispute with certain writers who attribute most cases of bad habit to perverted instinct, and who assume a congenital constitution whereby the mind of the patient—both in idea and in feeling—is naturally attracted by the person of some one of the same sex. Such cases are of extreme rarity. Nearly every case is one of perverse habit, not one of perverse instinct. To put the matter plainly and by the method of bald illustration, when a case comes before us of a man who shuns women and makes love to men, it is safe to assume that his sexual mechanisms were fairly normal in childhood, but that long association in immorality has given him an irresistible taste for the wrong thing. There are, however, genuine cases of congenital perversion, and it is hard to conceive any appropriate treatment of them short of segregation or castration.

Visceral Pain.

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XIV. OUTLINE OF THEORY CONCERNING THE RELATIONSHIP OF THE SYMPATHETIC SYSTEM TO THE CEREBRO-SPINAL 387

I. DEFINITION.—*Pain is a disagreeable sensation due to stimulation of some part of a cerebro-spinal sensory nerve or its centre, and referred to its peripheral distribution in the external body wall.*

The term cerebro-spinal used here has reference solely to the nerves arising from the brain and spinal cord, and distributed to the external body wall. Although the tendency is at present to regard the division of the nervous system into cerebro-spinal and sympathetic as obsolete, yet there are good grounds, to be shown in the following argument, for maintaining the distinction.

In the above definition it is contended that wherever the stimulation reaches the cerebro-spinal sensory nerve, whether in the brain, in the spinal cord, in the trunk of the nerve, or in its peripheral endings, the sensation of pain is referred to the peripheral distribution of the nerve. Thus in certain diseases of the brain, and in rare cases of epileptic aura, where the stimulation affects a part of the cortex of the brain, which is in connection with the sensory nerve, the sensation is referred to the peripheral distribution of that nerve. In diseases of the spinal cord, as in locomotor ataxia, the characteristic lancinating pains are referred to the peripheral distribution of the nerve. So also are the pains of herpes zoster, a disease of the ganglia of the posterior spinal roots. In this article the subject is limited to the study of the pain and certain other associated symptoms arising from disease of the thoracic and abdominal organs. From the study of the facts that will be detailed later the following conclusions have been arrived at: that pain is only felt in the peripheral distribution of a sensory cerebro-spinal nerve; that there is no evidence of sensory cerebro-spinal nerves being distributed to abdominal or thoracic organs; that the stimulation proceeding from those organs, which gives rise to pain, is conveyed to some part of the brain or spinal cord, there the stimulation affects some portion of a cerebro-spinal sensory nerve, and the pain thus arising is referred to the peripheral distribution of the sensory nerve so affected.

The view expressed in the above statement implies that the organs themselves are incapable of evincing pain or other sensation, as touch, sensibility to cold and heat, but that there is originated in them an impulse which passes by their nerves to the centre of one or more sensory nerves in the brain or spinal cord. The stimulation of these nerve centres evokes pain which is referred to the peripheral distribution of these nerves in the body wall.

II. Nerve Supply of the Viscera.—The chief nerve supply of the thoracic and abdominal organs comes from the sympathetic system. Nerve fibres pass out from the sympathetic ganglia to the various organs, and from the organs to the sympathetic ganglia. Nerve fibres pass from the spinal cord to the sympathetic ganglia, and from the sympathetic ganglia to the cord.

The functions of these nerves passing to and from the sympathetic ganglia are various, but are mainly concerned in regulating the functions of the various organs to which they are distributed. It is frequently assumed by experimental physiologists and others that certain afferent nerves in the viscera are "sensory" in function, and that certain ganglia are also "sensory." Except that these nerves run from the viscera to the cord, practically no proof has been adduced to support this assertion. Observations and experiments directed to ascertain the degree of sensibility of the viscera have demonstrated their insensitiveness. Pain, when evoked, has invariably been a referred pain.

The other nerves distributed to the viscera are the vagus and phrenic nerves. Branches of the vagus pass to most of the thoracic and abdominal organs. The functions of the vagus are numerous, but there is no evidence that it is a sensory nerve, yet there are grounds for assuming that it contains afferent fibres, which convey impressions that stimulate the centres of cerebro-spinal nerves. The phrenic, though mainly motor in its functions, has been demonstrated by Sherrington to contain afferent fibres. These convey impressions which stimulate the roots of sensory nerves in the spinal cord. Evidence of these statements will be given later.

If there be no sensory nerves distributed to the viscera, the question arises, by what mechanism is the symptom of pain brought about? That pain is evoked from affections of the viscera is a matter of which there can be no doubt. It is scarcely conceivable that a special arrangement of nerves should exist to cause pain and never be employed during a whole lifetime. Were the pain of angina pectoris, for instance, evoked through stimulation of cardiac sensory nerves, those nerves in the vast majority of people would never be exercised. The means by which this is brought about is probably by the excessive stimulation of the sympathetic nerves in visceral disease. The performance of the visceral functions passes unnoticed by the individual. From the brain and spinal cord to the viscera and from the viscera to the brain and spinal cord a flow of nervous impulse is nevertheless constantly maintained. When from any cause the strength of the afferent impulse is increased the stimulation arising in the brain or cord affects neighbouring cells which are in connection with nerves supplying skin and muscle of the external body wall. The individual then becomes conscious of this by feeling pain in the peripheral distribution of these nerve centres thus stimulated, and certain muscles likewise become tonically contracted or more readily liable to contraction, in order to protect the underlying viscera. Thus peristalsis of the bowel takes place and the individual is unconscious of the process. But when the peristalsis becomes violent he becomes conscious of the fact, but it is revealed to him as a severe pain in the nerves of the skin and muscle of the abdomen.

III. EVIDENCE OF THE INSENSITIVENESS OF THE VISCERA.—(*a*) *Experimental.*—Numerous experiments have been made on animals demonstrating the insensitiveness of the viscera. Haller, in 1752, published a series of observations where he had exposed the various internal organs and submitted them to a great variety of injuries without evincing the symptom of pain or other sign of discomfort in the animals operated upon. These observations have been in a great measure corroborated by later experimentalists.

(*b*) *Clinical.*—The clinical evidence is equally convincing, although the almost universal testimony of medical experience is seemingly opposed to this view. Medical men are daily finding evidence of what they assume to be sensitive organs. Pressure over an enlarged liver causes pain, or gentle pressure over the abdomen in peritonitis is felt as pain by the patient. This is too often supposed to be conclusive evidence of the tenderness of the visceral structures. This is, however, not evidence that the viscera are tender, the pain, as a matter of fact, being evoked by the stimulation of the hypersensitive external body wall covering the diseased organs.

Numerous instances occur scattered through medical literature where it has been observed that organs exposed in the human subject have shown no signs of sensation when stimulated. For many years I have taken every opportunity afforded me to test the sensibility of the viscera when the organs have been exposed through accidents or operative procedures. In the case of the heart and lungs the observations have been conducted on patients from whom a piece of rib has been removed for the relief of an empyema. The visceral layer of the pleura has never shown any sensation when pinched or pricked. The parietal layer has been equally insensitive, but when hard pressure has been made a sensation of pressure has been felt, evidently because the structures of the external chest wall were being pressed upon. In a few cases I have been able to reach the pericardium and exercise pressure against the heart. In no case has any sensation resulted.

In numerous cases I have been able to test the insensibility of the bowel. In one unique case I had an excellent opportunity of demonstrating this insensibility. The patient, a man aged fifty-six, had suffered from an umbilical hernia for many years. He had attempted to keep it back by tightly applied bandages. Ulceration of the skin followed, and this extended so deep at one place that the wall of the bowel (being adherent to the parietal peritoneum) was ulcerated through, and a fistula established. When I saw him, in consultation, I found in addition that an area of skin about three inches in diameter around the fistula was completely gone. It was resolved to attempt to suture the gut. The area denuded of skin being nearly insensitive, and as the patient objected to chloroform, we made the incision into the abdomen through the denuded surface. When the contents of the abdomen were exposed a portion of the bowel was drawn out, old and recent adhesions were broken down, a piece of the ulcerated bowel and underlying mesentery were removed, and the cut ends of the bowel sutured. All this was done while the patient was conscious and intelligent, and repeated inquiries during the operation elicited the statement that he felt no pain. Opportunity was also taken to demonstrate the insensitiveness of the liver. But there were times when he groaned and complained of pain. This occurred whenever the upper end of the cut bowel (small intestine) passed into peristalsis. This portion of the bowel was treated first and laid to one side of the abdomen. At varying intervals it would change from a large flaccid tube to a narrow fleshy rod. Whenever this occurred he groaned. Asked where the pain was felt he passed his hand over the umbilical region, although the contracting piece of bowel was at least twelve inches away.

IV. Nature of the Pain evoked by Stimulation of the Viscera.—Although no evidence of sensation is discoverable by direct stimulation, yet in some instances pain can be evoked when the stimulation is adequate. In the above instance pain was seen to occur when the non-striped muscular fibres contracted vigorously, but the pain evoked was not felt in the contracted bowel, but was referred to the region of the umbilicus. As I shall show later, this is the region to which the pain of the small intestine is usually referred. An adequate stimulus can be employed by causing non-striped muscles to contract, as by giving a distending enema and so stimulating the lower end of the great bowel to violent spasm. The pain then is always referred to the front of the abdomen below the umbilicus, and is not situated in the bowel itself. A pain in the middle of the forehead in many people is evoked on swallowing a piece of ice; the stimulation arising in the œsophagus, passing probably by the vagus, and stimulating a portion of the fifth cranial nerve.

One occasionally meets with other instances where the stimulus is adequate. Thus, Mr. Caird tells me that once, when incising the peritoneum above the pubis in a conscious patient, severe pain was felt but was referred to the point of the penis.

Pain of a referred character can sometimes be roused by exercising pressure on a glandular organ. It is difficult to differentiate between a pain actually due to an affected organ and the stimulation of the sensory nerve in its protective covering. It is for this reason that clinical observations are apt to be misleading. It may, however, be stated broadly that the sensibility of an organ or tissue to direct pain depends upon the amount of nerve supply from the cerebro-spinal system. So far as I am aware, apart from the vagus and phrenic nerves, no such supply has been traced to the abdominal or thoracic viscera. I have in several instances carefully dissected intercostal and abdominal nerves from their origin in the spinal cord to their peripheral distribution, but could detect no twig entering the pleura or peritoneum.

The demonstration of the truth of these assertions (the referred pain due to the stimulation of the parenchyma of an organ, and the direct pain due to the stimulation of the sensory covering of an organ) can best be shown in the study of the sensory relationship of the testicle.

V. The Sensory Supply of the Testicle.—For a long time I was hampered in the enunciation of the view that all pains arising from the viscera were referred pains, by the demonstrable fact that pressure on the testicle, as well as the pain in inflammation of that organ, called forth a direct pain. One day, while tapping a hydrocele, I laid hold of the testicle and touched the organ very lightly with the end of the canula. The patient immediately called out that it hurt, and referred the pain unerringly to the site touched. Shortly after I was demonstrating this symptom in another case of supposed hydrocele, where, however, the stimulation evoked no sensation whatever, and I concluded that this could not be a case of hydrocele. I subsequently operated on the patient, and found a small omenta hernia lying in a sac distended with fluid. What I stimulated in this case by the canula was the inside of the hernial sac, whose insensitiveness was therefore in striking contrast to the extremely sensitive testicle. The explanation is to be found in the fact that a branch of the genito-crural nerve is distributed to the testicle and its coverings. As the tunica vaginalis is in reality of the same origin and nature as the peritoneum, this is the only instance in the body of a serous membrane being supplied by a sensory spinal nerve. I do not think it would be straining the argument to state that the difference between the sensibility of the testicle and other viscera lies in the fact that the testicular covering alone is supplied by a spinal sensory nerve.

A pain of a different character and situation can sometimes be demonstrated on applying pressure to the testicle. If we take a patient with a long pendant testicle and apply pressure to the organ, the individual is sometimes cognisant of two pains, one at the point of pressure and another situated in the groin. In people with short cords it is not always easy to distinguish between the two pains, but with careful observation on an intelligent individual the distinction can be made out. This pain in the groin is evidently a referred pain. It is somewhat similar in situation and in character to the aching one finds in some cases of varicocele. It is also felt very severely in orchitis.

It is possible that pressure on the kidney and ovary may elicit a similar referred pain, but I have not had the opportunity of observing with sufficient exactness the nature of these pains on account of the confusion arising from the stimulation affecting the nerves of the external body wall.

VI. The Sensory Supply of the Orifices of the Body.—A difficulty arises in investigating the orifices of the body. The sensibility of mucous membranes appears to be distinctly limited to the areas supplied by spinal sensory nerves. Beyond the limits of the distribution of the spinal sensory nerves the sensation of pain when evoked is referred to some part of the body wall.

VII. Clinical Evidence of the Referred Nature of the Pain.—Confirmatory evidence of the referred character of the pain in visceral disease is shown in the distribution of the area of the pain in certain affections and in the presence of other symptoms associated with the pain, as hyperæsthesia of the external body wall.

(*a*) *The Radiation of Pain.*—If we consider the area in which pain is felt in certain forms of angina pectoris, we shall find that only by viewing the pain as referred can a suitable explanation be arrived at. Many patients complain of the pain in angina pectoris as starting over the præcordium. The pain, increasing in severity, passes outwards towards the left axilla, and strikes down the left arm, usually on the inner surface of the upper arm and ulnar border of the forearm. In some cases the pain is almost entirely limited to the arm. The area of the external body wall here described is one supplied by a series of spinal nerves whose spinal roots are contiguous, *i.e.* the fourth, third, second, and first dorsal nerves. The pain does not radiate up the chest as high as the clavicle, for the skin over the clavicle and on the chest as low as the second rib is supplied by the third and fourth cervical nerves.

The radiation of the pain in renal calculus affords a similarly striking evidence of the referred character of the pain. The pain in this complaint frequently begins in the back in the lumbar region, and passes round to the front, slanting downwards over the lower part of the abdomen into the testicle. Because the ureter runs in a somewhat similar direction for a short distance, it has been assumed that the pain was due to the stone scratching along that tube. But the course here described corresponds to the distribution of the twelfth dorsal nerve, and evidence of a hyperæsthetic condition of the tissues supplied by this nerve can often be demonstrated. A branch of the genito-crural nerve from the first or second lumbar nerve supplies the tunica vaginalis, and hence the extension of the referred pain to the testicle.

(*b*) *The Distribution of the Hyperæsthesia.*—A still more striking evidence of the referred character of the pain is to be found in an exaltation of sensibility of the tissues of the external body wall in the area where pain is felt. This hyperæsthesia or hyperalgesia is not present in all cases. When it does occur it corresponds in area with the situation of the pain. If we take the instances of heart pain or the pain of renal colic given above, we find most convincing evidence of the referred character of the pain. Thus in a patient suffering from disease of the aortic, mitral and tricuspid valves, the pain was first felt in the outer part of the left chest. This pain was followed by a tenderness of the skin which showed cutaneous hyperæsthesia well marked in the area shaded in Fig. 1. After several attacks the pain was felt over a more extensive area in the chest, and extended into the left arm. This area became also very hyperæsthetic, and corresponded to the shaded area in Fig. 2.

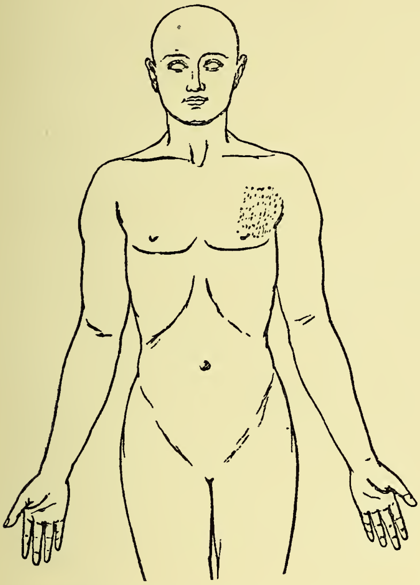


FIG. 1.—The shaded area shows the situation of the pain and hyperæsthesia after the first attack of angina pectoris.

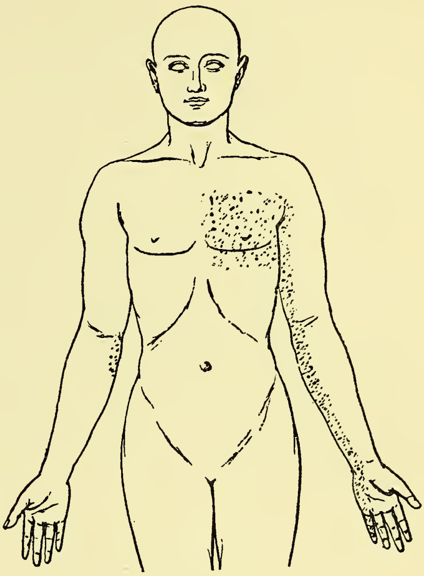


FIG. 2.—The shaded areas show the distribution of the pain and hyperæsthesia after repeated attacks of angina pectoris. Note that the inner surface of the right elbow was also hyperæsthetic, and the pain was also severely felt here.

The hyperæsthesia in renal colic shows a similar relationship of cutaneous tenderness with the area of pain. In Fig. 3 the shaded area shows the hyperæsthesia in a patient suffering from renal colic, who passed a small calculus a few days after the onset of the pain. The pain radiated to the testicle, and this organ was extremely tender on light pressure. It will be observed, however, that the shading showing the cutaneous hyperæsthesia stops short at the groin, the skin of the scrotum is not altered in its sensibility, while, as I have said, the testicle was tender to light pressure. The reason for this is that the shaded area represents roughly a portion of the area of cutaneous distribution of the twelfth dorsal and first lumbar nerves, and as the latter nerve also supplies the deep covering of the testicle, the testicle is tender to pressure. The skin of the scrotum receives its nerve supply from distant nerves, namely, the third and fourth sacral, and their centres in the spinal cord are therefore unaffected by the stimulation.

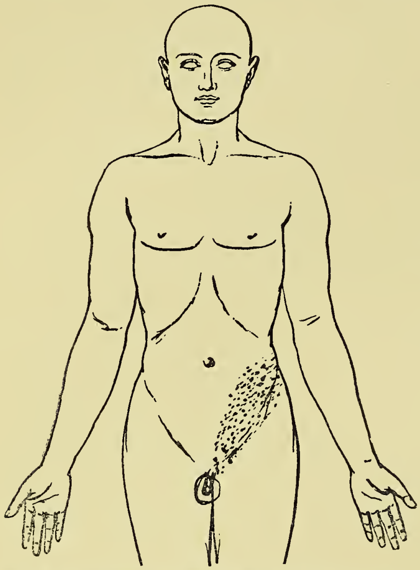


Fig. 3.—The shaded area shows the distribution of the hyperæsthesia in a case of renal calculus.

VIII. The Character of the Cutaneous Hyperæsthesia.—In a certain number of cases after an attack of pain due to some visceral disease, the tissues forming the external body wall become hyperæsthetic. This hyperæsthesia can be demonstrated to affect not only the skin but the deeper structures of the external body wall, more particularly the muscles. Glands such as the mammary also become tender to pressure. In addition to the tenderness of the muscles there is a great tendency for the muscles to become tonically contracted.

The hyperæsthesia of the skin shows itself in two forms. Sometimes the skin is so tender that the patient cannot bear the clothing to touch the part. At other times the light stroking of a pin calls forth the sensation of pain instead of that of touch. This form of hyperæsthesia may be called epidermic or superficial cutaneous, because it appears when the stimulus applied affects the surface of the skin.

Another form of cutaneous hyperæsthesia can be demonstrated when the skin is gently pressed between the thumb and forefinger. By this procedure we can elicit exalted tenderness, when the surface of the skin shows no increased sensitiveness. This deep cutaneous tenderness is always present with the superficial, and extends over a greater area than the superficial. Thus if one first map out an area of hyperæsthesia by gently stroking with a pin head, then map out the area by gently pinching the whole skin, the latter area will be found to be more extensive and to embrace the former area.

Another point to be made out is the fact that the borders of these areas are ill defined. In mapping out the borders one finds that the patient has sometimes difficulty in saying whether the skin tenderness is increased or not. Sometimes again while the patient has no doubt as to the increased sensitiveness, on again testing the same place after a few minutes the patient confidently asserts that the same place is not hyperæsthetic. While the edges of a given patch of hyperæsthesia are variable, the centre is usually invariable in its manifestation of increased sensibility. This same variability of the edges of an hyperæsthetic area is also present in the hyperæsthesia due to disease and to injury of the spinal cord itself. The reason is probably due to the fact that, as has been shown by Sherrington, neighbouring nerves overlap in their distribution, so that the same piece of skin is supplied by more than one nerve, and it is only when the centres of two neighbouring nerves are affected that an area of skin shows lasting hyperæsthesia.

The areas of hyperæsthesia, besides being of doubtful extent, are also of very irregular distribution. It is seldom that one gets the same exact distribution of hyperæsthesia in two individuals suffering from the same complaint. Since I first drew attention to the occurrence of hyperæsthesia as a diagnostic sign in visceral disease, an attempt has been made to map out the greater part of the body into areas supposed to represent the peripheral distribution of individual sensory nerves, by means of the hyperæsthesia present in visceral disease. But if these areas be carefully studied they will be found to afford no safe guide for such accurate delimitation. Hyperæsthetic areas undoubtedly occur in the field supplied by spinal nerves whose centres are associated with the sympathetic or other nerves supplying the viscera affected. But it is doubtful if a single nerve in its entire distribution is ever alone affected. The stimulation from the viscera seems to affect portions of the centres of several nerves that supply the same or contiguous areas of skin.

IX. Muscular Hyperæsthesia and Muscular Contraction.—It is only in recent years that muscles have been demonstrated to be provided with sensory nerves, notwithstanding the fact that hyperæsthesia of the muscles is a common and readily demonstrated symptom. In nearly all cases exhibiting cutaneous hyperæsthesia, muscular hyperæsthesia is also present. Muscular hyperæsthesia in such cases is not usually easily demonstrated, because pain is at the same time evoked by pressure on the skin when the muscle is stimulated. But a large number of cases which show no cutaneous hyperæsthesia readily show extreme tenderness when the muscle is stimulated. This muscular tenderness is often present with a readiness to contract when stimulated. The symptoms of muscular hyperæsthesia and muscular contraction are of much more frequent occurrence and of more clinical value than the cutaneous hyperæsthesia. They appear after an acute attack of pain, as after an attack of biliary colic, or they may be present in the absence of severe pains, where the patient complains only of a soreness when the muscles are pressed upon or when they are called into action, as in coughing or on taking a deep breath. In pleurisy the severe stabbing pain that is occasioned by deep breathing is due to the violent or spasmodic contraction of the hypersensitive intercostal muscles. Examination of these conditions of the muscles is best carried out in the broad muscular sheets that form the abdominal wall. These muscles possess the faculty of tonically contracting in their entirety or in sections. When all the muscles are contracted one feels the abdomen hard like a board. When only a small portion of the muscle is contracted, as in the case of a portion of the rectus muscle, between two intermuscular septa, the contracted muscle feels like a hard tumour in the abdomen. A similar deceptive feeling occurs when a piece of the internal oblique in the iliac region is contracted.

In addition to these contractions the muscle is always more or less tender. One can often observe that a muscle may be but slightly contracted when very gentle pressure is applied, and it may at once become hard and board-like on increasing the pressure. The muscle being at the same time hypersensitive, the increased pressure calls forth the symptom of pain. It is really this painful stimulation of the abdominal wall that observers so frequently mistake for the tenderness of the underlying viscera. Thus an enlarged liver, such as occurs in advanced heart failure, seems extremely sensitive to gentle pressure. If, however, one is able to lift gently a piece of the muscle away from the organ in suitable cases, by inserting the finger into the umbilicus, and gradually compress the muscle, the tenderness will be found to be in the muscle. Or, after carefully mapping out the lower border of the liver, the tenderness will be found to extend over a greater area than the liver.

This tenderness of the muscles of the abdominal wall is often mistaken for local peritonitis. One finds frequent statements to that effect in recent text-books. I have known a very experienced surgeon diagnose a local peritonitis after an attack of gall-stone colic because of this muscular tenderness. Yet this tenderness was present not only in the muscles of the abdominal wall, but extended to the muscles in the thorax, as high as the pectoralis major. So tender indeed may the muscles of the right side of the thorax become after an attack of gall-stone, that I have seen it ascribed to an attack of pleurisy.

X. The Spreading of Symptoms.—The spreading of the stimulus to nerve centres in the spinal cord has been incidentally alluded to in the case of heart and renal pains, and illustrated in Figs. 1, 2, and 3. This spreading may affect other than sensory nerves. Thus muscular spasm may be set up in parts more or less remote, and give rise to misleading symptoms. In a severe case of renal colic due to a calculus in the pelvis of the kidney or in the ureter, the whole of the abdominal muscles may be thrown into strong contractions. Not only may the muscles forming the anterior abdominal wall be affected, but the sphincters may become strongly contracted, the result being that neither flatus nor fæces can be passed. After a few days the abdomen may become so distended that there is presented a variety of symptoms closely resembling those of obstruction of the bowel. Careful attention to the history of the case and to the site of the pain will aid in arriving at a correct conclusion.

The spreading of the stimulus to the sensory nerves may be revealed in other ways than by cutaneous and muscular hyperæsthesia. So sensitive do the centres of the spinal nerves become, that however the stimulus reaches them pain is evoked. Thus after an attack of gall-stone colic ingestion of the food into the stomach sometimes causes great pain referred to the epigastrium. The explanation seems to be that the centres of the sensory nerves in the spinal cord are so extremely sensitive that any stimulus reaching them evokes the sensation of pain. The ingestion of food sends a stimulus, probably by the sympathetic, to the spinal cord, and this, which under ordinary circumstances gives rise to painless stimulation, now produces the symptom of pain, just in the manner that a light touch to the hyperæsthetic skin gives rise to a sensation of pain. It is a matter of common experience to find organs remote from the part stimulated affected in their functions. Thus nausea and vomiting are common in labour, in renal and hepatic colic. The secretion of glands may be affected, as in the intense salivation sometimes present in angina pectoris. While the symptoms are often limited to one side of the body, the stimulus may affect the spinal roots supplying the opposite side. Thus the heart pain sometimes radiates to the right arm (see Fig. 2).

XI. Tender Nerves and Tender Spines.—The small nerve-trunks running to the regions in which pain is felt may become very tender to pressure. As several of these have a permanent situation and are readily accessible to pressure, the points of tenderness have sometimes a diagnostic significance. Thus a branch of the ninth dorsal nerve as it pierces the sheath of the right rectus muscles two inches from the middle line, and a little higher than the level of the umbilicus (Fig. 4) is frequently sensitive in gall-stone colic. In cases of doubt I have come to look upon it as almost diagnostic of that disease. So also a twig of the twelfth dorsal nerve as it crosses the iliac crest three inches behind the anterior superior iliac spine is frequently very tender in renal colic due to a calculus. A small twig from the first dorsal nerve (the internal anterior thoracic) is sometimes tender in heart affections as it courses over the second and third left ribs in the nipple line.

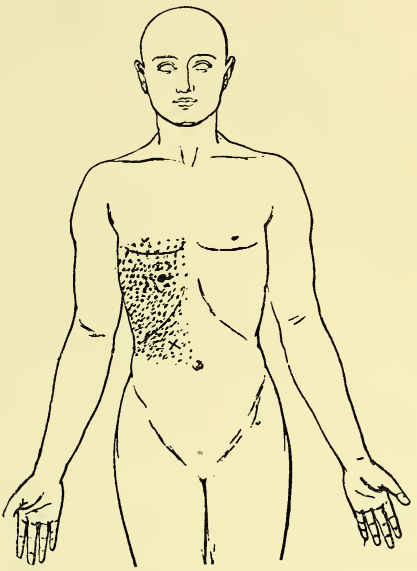


FIG. 4.—The shaded area shows the distribution of hyperæsthesia in a case of gall-stone colic. The X indicates a spot very commonly tender to pressure in this complaint.

Certain vertebral spines have a tendency to become tender on pressure, and to resemble the tenderness due to diseases of the vertebra. This spinal tenderness, when associated with a band of hyperæsthesia, is sometimes mistaken for spinal disease. I have found the upper dorsal spines tender to pressure in heart disease, the fourth to seventh dorsal vertebra tender in affections of the stomach, and the sixth to the ninth tender in hepatic colic. This tenderness is not due to the pressure applied to hyperæsthetic skin covering the spinous processes, for it is present when pressure is applied, when neither the skin nor deeper tissues are hyperæsthetic.

XII. VISCERAL AND CUTANEOUS MUSCULAR REFLEXES.—The muscles of the external body wall are influenced in a two-fold manner by visceral affections. In Paragraph IX. attention was drawn to the muscular contraction in visceral disease. This may be spoken of as a *viscero-muscular reflex,* inasmuch as the stimulation passes from the affected viscera by the sympathetic to the centre of the muscle nerves in the cord. It is characterised by long-continued contractions of the muscles, and is in striking contrast to the short rapid contractions of the cutaneous muscular reflex.

Another peculiarity is that the muscular contraction due to visceral stimulation does not readily relax under chloroform anæsthesia. Thus we may push the anæsthetic till all the other voluntary muscles are relaxed and sensation abolished, and still the visceral stimulated muscle remains contracted. This is particularly the case with the abdominal muscles, where the rigid recti sometimes interferes with the surgeon's freedom. In a case of stone in the bladder I found the lowest segment of the left rectus muscle firmly contracted and tender on pressure. It remained so during complete anæsthesia and till the bladder was opened (supra-pubic operation). The patient became sick and the muscles relaxed and did not again contract.

A number of causes produce the muscular contraction, as contraction of hollow muscular organs, inflammation of the peritoneum, affections of the parenchyma of organs, etc. When more is known of the exact relationship of the sympathetic nerve supply to the cerebro-spinal nerves, this symptom will be of great diagnostic value.

With hyperæsthesia of the skin there is also increase in the activity of the muscular reflexes. This is well illustrated in gastric affections with hyperæsthesia of the skin of the epigastric region. A slight stroking of the skin here will call forth strong rapid contraction of the upper portion of the left rectus muscle. Not only is the muscular response abnormally easy to elicit, but it may also be called forth by stimulation of the non-hyperæsthetic skin at a remote distance, as, for instance, by stimulating the skin in the axilla. This would point to the fact that the centres of the muscular nerves are abnormally sensitive to stimulation.

XIII.—Sensory Symptoms of Individual Organs.—Before dealing with the sensory symptoms of individual organs it is necessary to state that it is often impossible to locate with certainty the cause of many pains. It is difficult to tell for instance whether any given pain may not arise from affections of the body wall itself. A pain over the lower part of the back may be a referred pain from some internal organ, or it may be due to some rheumatic affection of the muscles, as lumbago. Severe pains in the arm may be of peripheral origin, as in some forms of neuralgia, or they may be due to an affection of the heart. Again, there may be diseases which affect more than one tissue. Thus appendicitis may set in with severe peristalsis of the bowel, giving rise to the characteristic cramp-like pains. With extension of the disease a peritonitis may be set up with the characteristic sensory phenomena. Suppuration may follow in the tissues of the abdominal wall, producing pain and other symptoms of a purely local character.

There are often indefinite pains which are difficult to locate, particularly as many patients describe the sensations in very vague language. It often happens that the pain is felt in a somewhat diffuse fashion. In speaking of the spread of the hyperæsthesia I drew attention to the fact that it spread along districts supplied by portions of nerves whose roots were contiguous, and did not embrace the whole distribution of any one nerve. As visceral pain often occurs without any hyperæsthesia being present, we are dependent entirely on the patient's description for discovering where the pain is felt. The patient frequently gives a totally wrong description of the site when describing it from memory. But if asked to note carefully the place where the pain is felt during a subsequent attack, much more reliable information can usually be obtained. But even after that there are a great many pains which, in the present state of our knowledge, it is impossible to locate with certainty.

In describing the pains and other sensory phenomena associated with visceral disease, it will be better to consider the subject from the standpoint of the tissues affected, rather than from the point of view of the organ as a whole. Certain kinds of tissue give rise to pain that bear a somewhat similar resemblance in character. Those organs containing non-striped muscles present a certain similarity of symptom, while affections of the membranes present a different kind of symptom. For this reason the subject will be considered according as the pains are associated with (*a*) hollow muscular organs, (*b*) serous membranes, (*c*) parenchymatous tissue.

(*a*) *The Hollow Muscular Organs.*—In a great number of instances there is a certain resemblance between the character of the pain in affections of the hollow muscular structures. It has been pointed out in describing the peristalsis of the bowel in Paragraph III. that coincident with the contraction of the bowel a pain was felt. The character of the pain was typical. It gradually increased in intensity, reached its height, and gradually subsided. The character and duration of the pain agrees with the character and duration of the muscular contraction. The muscle contracts slowly, increasing in force till fully contracted, and then gradually relaxes. Such is the character of the pain to be found at times in all hollow muscular organs—the digestive tube, gall-ducts, ureter, bladder, uterus. In the heart a pain of a similar character may occur, but there is no reason to suppose that the muscle remains spasmodically contracted, seeing that there may be no interference with the rhythm of its contraction. In other instances the pain may not have this definite wavy character. The contraction of the tube may continue for a longer period, and pain of the most intense character may persist for hours. Or the contraction may be less severe and the pain less intense.

There is a tendency for organs that are single to have the pain referred to the middle line, though it may radiate to one side. Thus the cramp-like pains due to severe peristalsis of the bowel are almost invariably situated across the middle line. So also are the uterine pains and pains due to contraction of the bladder. The pain of the stomach is also most often felt in the middle line, but generally radiates to the left, while the pain in gall-stone colic, also frequently situated in the first instance in the centre, radiates generally round the right side of the body. The pain due to renal calculus is always one-sided. The pain from the heart is often felt across the breast bone, but usually radiates towards the left side.

The Digestive Tube.—It cannot be demonstrated in all cases what it is that actually causes the pain in affections of the digestive tube, but in a great many cases it can be reasonably inferred that strong peristaltic contraction of the muscle is the exciting cause. Thus, if we study the symptoms of obstruction of the bowel, it will be found that the portion of intestine above the obstructed point is at times thrown into strong peristaltic contractions, and at the same time severe pain is felt. If the situation of the pain be noted it will be found to bear a distinct relationship to the piece of bowel in which the increased peristalsis occurs. Thus the spasm of the muscular wall of the stomach causes pain to be felt in the epigastrium, spasm of the small intestine about its middle causes pain in the umbilical region, and spasm of the lower end of the great bowel causes pain above the pubis. Pain felt in places between these points would indicate peristalsis of a portion of bowel higher or lower than those parts mentioned, according as the site of pain is higher or lower in the abdomen. Apart from cases of obstruction, one finds evidence of the truth of this view in cases of severe abdominal pain, when the contents of the bowel set up violent peristalsis. Thus the pain may be felt higher than the umbilical region. A desire to have the bowels relieved may be felt by the patient, but no relief is obtained. The pain continues, but gradually descends, is felt in the umbilical region, then gradually lower, till it is felt above the pubis, when the necessity for relief becomes at once urgent, and with relief of the bowels the pain ceases. Here it is evident that the peristalsis has been driving the contents of the bowel lower down, and as parts of the bowel passed into violent peristalsis the pain was felt lower in the abdomen.

While the above statement holds true for the digestive tract as a whole, it also holds true for more limited portions. Thus, if the situation of pain in gastric ulcer be studied, an idea can be formed of the site of the ulcer. In the majority of cases of gastric ulcer there is a localised pain referred to the middle line in the epigastrium. The patient can often put the finger on a certain spot and say with decision that here the pain is most intense. There is often found at the same time a limited area of hyperæsthesia. If the situation of this pain be high up in the epigastrium, as in the dotted area in Fig. 5, the site of the ulcer will be near the cardiac orifice of the stomach. The X marks the position of the ulcer in relation to the external body wall in one particular case. If the site of pain be felt in the middle of the epigastrium, as in the dotted area of Fig. 6, the ulcer will be found near the middle of the stomach. Fig. 6 is from a patient who had a ruptured gastric ulcer, and the site of the ulcer was reasoned out from the position of the pain previous to the rupture. The patient was operated upon within fifteen hours of the rupture; the perforation was found in the middle of the stomach on the lesser curvature, was sewn up, and resulted in a good recovery. I mention this, as the knowledge of where to look saved the risk of blindly exploring, whereby the contents of the stomach might be squeezed out of the perforation. When the site of pain is low in the epigastrium, as in the dotted area of Fig 7, the ulcer will then be at the pyloric orifice of the stomach. The above reasoning may not be absolute, nevertheless I have found it invariable in over a dozen cases, where the position of the ulcer has been verified by post-mortem examination or by operation. It occasionally happens that the localised pain is not situated in the epigastrium, but when we know more of the exact relationship of the stomach and the skin areas the localised pain will become a guide to the site of the ulcer. While there may be a localised pain in gastric ulcer, the pain and hyperæsthesia may radiate very widely. Usually it passes round the left side. A band of hyperæsthesia passing from the epigastrium round to the back, with the seventh and eighth spines tender to pressure, may simulate disease of the vertebræ. The hyperæsthesia may extend widely up into the chest and down into the abdomen. The epigastric reflexes in such cases are always greatly exaggerated. It is not easy to decide on the immediate cause of the pain in gastric ulcer and indigestion. There is absolutely no evidence of sensitiveness of the mucous membrane. Contraction of the muscle does give rise to pain, and it is possible that it is the muscular coat that is affected, being more readily stimulated to contraction on account of the disease. In Beaumont's experiments on the man with the gastric fistula the only record of pain arising from his stimulation of the internal surface of the stomach occurred when he produced strong contraction of the pyloric end.

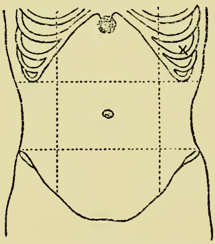


Fig. 5.—The shaded area shows the site of pain; X corresponds to the position of the ulcer.

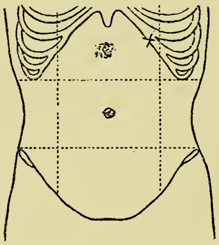


Fig. 6.—The shaded area shows the site of pain; X corresponds to the position of the ulcer.

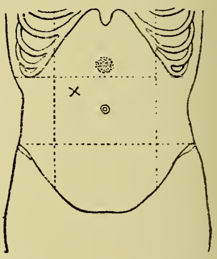


Fig. 7.—The shaded area shows the site of pain; X the site occupied by the ulcer at the pyloric orifice of the stomach.

Gall-Ducts.—The first onset of pain in gall-stone disease may suddenly become very severe. It is often referred to the middle line, in the lowest part of the epigastric region and adjoining part of the umbilical region. From here it may radiate widely across to the left side, but more usually it passes round the right side over the lower ribs to the back to the right of the eighth, ninth, and tenth dorsal vertebræ, and here the pain may also be felt with great severity. The attack of severe pain may last for many hours, and be accompanied by severe nausea. The attacks may gradually pass off and not recur for some lengthened period, or they may recur with such frequency that the patient is seldom free from pain for weeks and even months. After a severe attack of pain there is often extreme hyperæsthesia of the external body wall. It was in a patient suffering from this complaint that I first made the observation of hyperæsthesia in visceral disease. A few days after an attack of colic he called on me holding his right arm stiffly away from his body. Asked why he adopted this attitude, he replied that the contact of his clothes to his skin caused him great pain. On stripping him I found an area of cutaneous hyperæsthesia corresponding to the shaded area in Fig. 4. The hyperæsthesia in cases of gall-stone colic may extend more widely and be present in the muscles not only of the abdominal wall, but as high as the right pectoralis major. I have already mentioned that ingestion of food may also cause pain, and for this reason such ailments may be mistaken for diseases of the stomach.

Many cases of gall-stone colic are difficult to diagnose because of the vagueness of the symptoms. In many such doubtful cases I have found almost convincing evidence in the presence of a spot peculiarly tender to light pressure, exactly in the position of the X in Fig. 4. Here a twig of the ninth dorsal nerve emerges from the muscle and is readily affected by the pressing finger. This observation I find has been independently observed by Mayo Robson, whose practical knowledge of this disease is very extensive.

The cause of the pain in this disease I assume to be due to the strong contractions of the muscular coat of the gall-bladder or gall-duct upon the stone, the latter acting as the exciting cause. The hyperæsthesia results from over-stimulation of the centre in the spinal end of the nerves supplying the lower part of the chest and upper part of the abdomen, and these centres remain abnormally excitable after the muscular spasm has relaxed.

The cutaneous and muscular tenderness are often stated to be evidence of an accompanying peritonitis, but it is not necessarily so. While doubtless a localised peritonitis may accompany gall-stone disease, and hyperæsthesia be a symptom of peritonitis, yet hyperæsthesia is such a constant accompaniment of muscular spasm that we are not justified in diagnosing peritonitis from its presence.

Ureter.—The pain arising from a stone either in the pelvis of the kidney or in the ureter is usually very well defined in its distribution. It begins in the back in the lumbar region, radiates round the side, and descends the front of the abdomen in a slanting direction to the level of the pubis. In the male it generally strikes into the testicle. There is also frequently present a good deal of hyperæsthesia of the external body wall. The cutaneous hyperæsthesia when present has a distribution corresponding to that shaded in Fig. 3. But it may be more extensive, passing down over the upper part of the thigh. On the other hand, only a small patch in the shaded area may be present. The deeper structures, and particularly the muscles of the back and front of the abdomen, are often very tender. This muscle tenderness is usually limited to the side affected, but, as I have already said, it may affect all the muscles of the abdomen. This tenderness of the muscles in the lumbar region is often assumed to be evidence of a tender kidney, as patients wince when pressure is applied. Careful examination of the muscles reveals the tenderness to be in them. A branch of the twelfth dorsal nerve passes over the iliac crest three inches from the superior anterior iliac spine, and light pressure applied over it sometimes causes pain. The testicle itself is often very tender to light pressure due to the hyperæsthesia of its tunica vaginalis. It will be noted that the skin of the scrotum is never hyperæsthetic, as its nerve supply is from the remote sacral nerves. This testicular tenderness is often diagnostic in these obscure cases where one has some difficulty in deciding from the patient's account whether the pain is really due to renal calculus.

Although the pain here described is most commonly associated with renal calculus, yet any other condition that gives rise to spasm of the muscle wall of the ureter will cause these symptoms. Thus, I have seen it associated with a collection of pus in the pelvis of the kidney or ureter, and it may be present with a movable kidney.

The Bladder.—The pain due to the bladder is not easy to localise. The functions of the bladder are so intimately associated with structures that are supplied with sensory nerves (as the sphincters and urethra) that it is difficult to tell whether they may not be affected. I have seen intense backache felt over the top of the sacrum in retention of urine due to spasm of the sphincter in women at once relieved on emptying the bladder. In spasm of the bladder due to cystitis or due to a stone in the bladder, the pain is commonly referred above the pubis, or in the perineum, and in the male along the urethra to the end of the penis, and the perineum may be hyperæsthetic. The sympathetic supply of the bladder is two-fold, from the hypogastric plexus and from the third and fourth sacral nerves. The pain over the sacrum and above the pubis is probably due to the nerves associated with the hypogastric plexus, while the pain in the perineum and penis is due to the stimulation affecting the sacral nerves.

The Uterus.—The symptoms connected with disease of this organ are also complicated by its association with structures (as the cervix and vagina) supplied by sensory spinal nerves. In scraping the uterus, for instance, local pain is felt in stretching the cervix, but the scraping of the interior of the uterus is painless. The pain in labour is characteristic of the pain due to the contraction of non-striped muscles. Its gradual onset, increasing in severity, lasting for a shorter or longer period at its fullest intensity, then its gradual relaxation, corresponds in character and duration to the pain felt in other hollow muscular organs. That this pain is usually supposed to be in the uterus is easy to understand, as the coincidence of the pain with the contraction of the uterus is readily demonstrated. But there are other points that lead one to a different conclusion. Thus the pain is often entirely limited to the back, about the top of the sacrum. This has hitherto been explained as being due to pressure of the child's head upon nerves, as the lumbar plexus, or to stretching of the cervix. But as pressure upon nerves gives rise to pain in the peripheral distribution of the nerves, and as the nerves of the lumbar plexus are not distributed in this region, that cannot account for the pain. Further, the same pain is felt in this region when the uterus is small, with no child's head to complicate matters, as during the after pains, as it is when the uterus is large and extends high in the abdomen.

The pain in labour is also felt across the abdomen, referred usually to the lower part, whether the uterus is full and large, containing a full-time child, or when it is small and situated entirely in the pelvis. In a few cases I have seen extreme pain result from the entrance into the womb of water while the patient has been syringing the vagina. The intense pain over the lower part of the abdomen, induced evidently by spasm of the uterus, has been accompanied by great hyperæsthesia, and such tenderness of the abdominal muscles that the condition resembled what one finds in acute peritonitis. On rare occasions I have found the pains in labour almost entirely referred to the upper part of the thigh.

The Heart.—There are two very striking points in connection with the pain in heart affections: first, that hearts similarly diseased may exhibit a great difference in regard to the sensory symptoms. Thus, in cases of aortic disease, pain may never be present, while in other cases pain of the most intense description is a characteristic feature. In degeneration of the heart muscle and in disease of the coronary artery the same uncertainty in regard to the presence of sensory symptoms is found. The second point is that pain and the other sensory phenomena when present do not afford of themselves a clue to the nature of the disease, as one finds a similarity of symptom in the most diverse forms of disease.

The consideration of these points suggests that the pains may have a common origin, and so far as I have been able to reason out the subject, I am disposed to view them as being essentially due to muscular stimulation. In the great majority of cases with heart pain, the attacks come on when the weakened organ is exposed to a strain beyond its strength. Thus hill-climbing is a fruitful source of heart pain in all predisposed subjects. Vaso-motor contraction is another frequent cause, as when a susceptible patient is exposed suddenly to cold, as on going out of a warm house on a frosty morning. Vaso-motor contraction also causes the pain in the attacks of increased arterial pressure seen often in the elderly, the gouty, and the subjects of Bright's disease.

The similarity of the attacks of pain in heart affections to the pain of other hollow muscular organs is also very striking.

The pains are usually felt in two fields, namely, in the areas of distribution of sensory nerves whose roots are associated with the nerves supplying the heart, viz. the sympathetic and the vagus. The sympathetic nerve supply is associated with the upper dorsal spinal nerves, and it is in the field of distribution of these nerves that the most typical sensory symptoms are shown. Thus the most common site of the pain is over the chest, across the middle line, or in the left side, sometimes as far out as the shaded area in Fig. 1. From here the pain radiates usually upwards to the axilla and down the left arm. The shaded area in Fig. 1 shows the site of pain and hyperæsthesia of skin after the first attack of angina pectoris in one case. The shaded area in Fig. 2 shows the area of pain and hyperæsthesia after the attacks had increased in frequency and in severity. It will be noted that the inner side of the right elbow had become also hyperæsthetic and the patient felt the pain here also.

On the whole, hyperæsthesia is not common after attacks of angina pectoris, some of the most severe cases showing no tenderness of any part of the chest wall. But the distribution of the pain has a very striking resemblance to the areas found hyperæsthetic in certain equally typical cases. In rare cases the pain may be entirely limited to the left arm.

The pain is usually assumed to be in the heart when it is limited to the chest. Seeing that it is continuous with the spreading of the pain to remote parts, as the left arm, and that it is associated at times with demonstrable hyperæsthesia of the external body wall, it seems more reasonable to assume its situation to be in the nerves thus rendered hyperæsthetic. It is sometimes entirely limited to the arm, and one of the most typical cases of angina pectoris that I ever saw had the pain entirely limited to the left forearm. Again, the pain may be limited entirely to the epigastrium. The pain may be situated in other portions of the field of supply of these nerves, as the side or back of the chest. In certain heart cases a field of pain and muscular tenderness is found to occur in the neck, the top of the shoulder, and the back of the head on the left side. When the sterno-mastoid or the upper border of the trapezius muscle is lightly pinched, tenderness, sometimes exquisite, is complained of by the patient. I have observed cases where this tenderness was almost the only symptom beyond weakness in cases of heart failure, and the patient's recovery was coincident with a diminution and ultimate disappearance of this tenderness. This field of pain and tenderness is probably occasioned by a stimulus passing upwards by the vagus nerve. The origin of the vagus and spinal accessory nerves are so closely associated that one is forced to conclude that the stimulus proceeding by the one has affected either the spinal accessory nerve itself or the sensory nerves associated with it in its distribution.

(*b*) *Serous Membranes.*—I have already pointed out that the tunica vaginalis is the only serous membrane that is supplied by a spinal sensory nerve. Serous membranes lining the great cavities of the abdomen, thorax, or skull, are insensitive to the ordinary means of stimulation. Pain and other sensory symptoms when evoked can be demonstrated to be present only in the tissues forming the external body wall exclusive of the serous membranes.

Peritonitis.—The pain and tenderness in this complaint can readily be demonstrated to exist either in the skin or muscles. In acute peritonitis the patient assumes a characteristic attitude—the abdomen is kept rigid by the contracted muscles, the legs are drawn up, and the respiration is almost entirely thoracic. There may be the most extreme tenderness on touching the abdomen. On careful examination this is found to be due to superficial cutaneous hyperæsthesia, and it may extend some distance beyond the limits of the peritoneum. Thus, Fig. 8 shows the distribution of this hyperæsthesia in a patient suffering from acute peritonitis following upon the rupture of a gastric ulcer into the peritoneal cavity. It is seen that the hyperæsthesia not only extends up into the chest but invades to a slight extent the skin of the thigh. In the absence of the superficial cutaneous hyperæsthesia one can readily demonstrate that the tenderness on pressure in peritonitis is either in the deeper skin or in the muscles. If one gently lifts a portion of either of these structures away from the peritoneum by deftly inserting the finger into the umbilicus, and then applying pressure, the characteristic pain is felt. In other cases where the muscle is not strongly contracted it can be made to do so by gently irritating with the point of the finger.

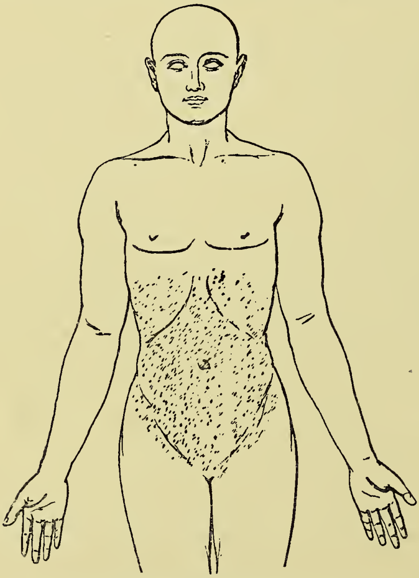


Fig. 8.—The shaded area shows the distribution of the superficial cutaneous hyperæsthesia in a case of acute peritonitis.

This hardness of the muscle is often mistaken for a thickened peritoneum, and its presence on the other hand is often assumed to be evidence of peritonitis. It is necessary to insist on the fact that hardness and tenderness of the abdominal muscles may exist entirely independently of any sign of peritonitis, but may be due to affection of other tissues, as in simple gastric ulcer, renal and hepatic colic.

Pleurisy.—The pain in pleurisy may be felt immediately over the inflamed pleura, or it may be referred to a portion of skin some distance off. When its situation is immediately over the area of friction it is difficult to prove whether after all it may not be situated in the pleura. Frequently, however, it is accompanied by a hyperæsthesia of the external body wall, either of the skin or muscles, and the fact that the pain and hyperæsthesia correspond in situation leads one naturally to the conclusion that the pain is in the tissues that are hyperæsthetic. This conclusion is all the more feasible when the pain and the tenderness are remote from the inflamed area. When the pleurisy affects the diaphragmatic pleura the pain is usually situated in the abdomen, sometimes as low down as the umbilicus, as in the shaded area in Fig. 9. The pain in this site is not infrequently associated with hyperæsthesia of an irregular patch of skin and a certain amount of muscle tenderness and contraction. This would suggest that the stimulus has passed by the sympathetic nerves to the spinal cord and irritated the roots of the spinal nerves supplied to the abdomen. In rare cases this diaphragmatic pleurisy is associated with great pain on the top of the shoulder, and I have on rare occasions found an area of hyperæsthesia here (B in Fig. 9). Ross drew attention to this shoulder pain and explained it by reference to the fact that this area is supplied by the fourth cervical nerve, and the phrenic nerve also comes from the fourth cervical. It may be that as the phrenic contains afferent fibres these convey the stimulation to the root of the sensory nerve, or it may be that the stimulus proceeds by way of the vagus. But there is no doubt as to the close association of this area of skin with the diaphragmatic pleura. The most severe pain in pleurisy is that due to the spasmodic contraction of the intercostal muscles. Just as the abdominal muscles contract on the slightest stimulation in peritonitis, so these hyperæsthetic intercostal muscles are stimulated to violent contraction by the movements of respiration in pleurisy.

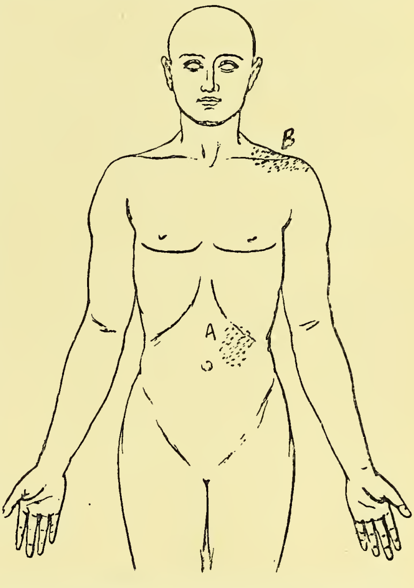


Fig. 9.—The shaded areas *A* and *B* show the situation of pain and hyperæsthesia in diaphragmatic pleurisy.

Meningitis.—I have not sufficient data to establish satisfactorily all the sensory symptoms in this disease, but there is no reason to suppose that it differs from the general characteristics of disease of the other serous membranes. That it is, like the pleura and peritoneum, insensitive to stimulation I have been able to demonstrate in wounds of the skull. That it is characterised by the same tendency to muscular contraction is evidenced by the rigid way in which the contracted muscles of the neck hold the head.

The Pericardium.—In the great majority of cases pericarditis is not associated with any sensory symptoms. In the rare cases that I have found them, they seemed to resemble the symptoms present in heart affections generally, due probably to an extension of the inflammation to the muscle wall. Thus in one well-marked case there was great pain in the left chest, extending down the inside of the arm.

(*c*) *Affections of the Parenchyma of Organs.*—I am extremely doubtful how far disease of organs, apart from their serous coverings, can exhibit sensory symptoms. It is well understood, for instance, that the lungs may be deeply excavated with phthisical cavities and pain may never be felt. It might seem that even in inflammation of the lungs there is no pain unless there be an accompanying pleurisy. At all events the pain and other sensory symptoms that we associate with pneumonia are identical with those observed in attacks of pleurisy, and one occasionally meets with cases of pneumonia with absolutely no pain, probably due to the fact that the pleura is not invaded. The pain and hyperæsthesia in the areas in Fig. 9 are sometimes associated with pneumonia of the base of the left lung. It is also a matter of common experience that affections of other organs are usually painless. Thus the bowels may be largely ulcerated, the kidneys acutely inflamed, and the patient never complain of pain. I have observed pain, muscle contraction, muscle tenderness, and cutaneous hyperæsthesia accompany acute enlargement of the liver due to heart failure. But I could not convince myself that the symptoms may not have been due to the sudden stretching of the capsule, just as in acute orchitis the pain, local and referred, may be due to the stretching of the tunica vaginalis.

In ovarian affections great caution has to be exercised in demonstrating the symptoms present. A widespread hyperæsthesia, sometimes of a purely hysterical nature, is so liable to occur that no safe deduction can usually be drawn. I may, however, point out that ovarian tenderness is often described because of the pain felt on pressure being applied "over the ovaries" in the iliac region. If one studies the position of the ovaries in the pelvis it will be recognised that pressure applied here is not likely to directly affect the ovaries. In ovarian disease pain and hyperæsthesia is often present in the iliac region, and the application of pressure here calls forth the pain because it is the hyperæsthetic tissues that are being pressed upon. It often happens that the muscles here are slightly contracted as well as tender, and this tenderness is not infrequently assumed to be due to inflammatory adhesion.

The only instance where I have found what seems to be pain due to stimulation of an organ is on applying pressure to the testicle. In some cases of long pendant testicles the local and referred pain can be very instructively illustrated. Thus a man who in his employment had to lift heavy weights, complained of aching in the groin and down the inside of the thighs, particularly on the right side, had a long scrotum with the testicles at the bottom. The right testicle was small and sensitive, and on applying pressure he felt at once pain in the testicle, and then a few seconds after he groaned as if in great pain and said he felt another pain come on in the groin and down the inside of the thigh. The first pain is evidently due to stimulation of the genital branch of the genito-crural nerve, as it supplies the tunica vaginalis; the second is a referred pain due to the stimulation passing by the sympathetic to the centre of the first lumbar nerve in the spinal cord producing the pain in the region of the distribution of that nerve. This latter pain was not only delayed, but gradually grew in intensity and gradually subsided, and was accompanied by the peculiar sensation of depression characteristic of visceral pain.

XIV. OUTLINE OF THEORY CONCERNING THE RELATIONSHIP OF THE SYMPATHETIC SYSTEM TO THE CEREBRO-SPINAL.—The view expressed above implies that the functions of the cerebro-spinal system of nerves and of the organs supplied by these nerves are primarily for the defence and protection of the organs necessary for the maintenance of life. The joining together of the muscles and nerves in the visceral and cutaneous muscular reflexes is evidently purposed for the protection of the economy. This view of the matter further suggests a theory of development which explains the reason for the division of pains into local and referred. In the lowest scale of animal life digestion is the principal function, and in the early stages of evolution a digestive cavity is the first semblance of an organ to appear. This is followed by a rudimentary circulatory system to carry the digested fluid to the different regions of the body. After this comes a respiratory system to purify the blood. These various organs are co-ordinated by a rudimentary system of nerves which are manifestly the antecedents of the sympathetic system. So far the external body wall is not differentiated, but is mainly a protective encasement. In further development this covering gives place to contractile and sensitive structures, so that the economy is protected from external injuries by a sensitive covering which, on painful stimulation, causes reflex action of certain muscles, and the animal is thereby removed from the offending neighbourhood. Herbert Spencer elaborates a similar idea to account for the vertebral segmentation. The nervous supply of the protective covering and that of the viscera are co-ordinated in the cerebro-spinal nervous system.

The view that the sympathetic nerve system originates independently of the cerebro-spinal system is supported by other considerations. It may be accepted as an established dictum that the more recently evolved structures are more liable to change and to disease. The period of mental growth in the human being, for instance, as well as the gradual acquisition of faculties, as speech and dexterity in manual acts, point to an increase in the functions of the brain and spinal cord, whereas the functions of the sympathetic system are as efficiently performed at birth as during later life.

It is a matter of common experience that disease is extremely frequent in the cerebro-spinal system, with a tendency to affect the most recently acquired functions, whereas disease of the sympathetic system is of rare occurrence.

The same distinction between the two systems is seen in their susceptibility to the influence of drugs. In the administration of chloroform the higher intellectual centres are the first to be affected, and after the loss of consciousness follows the abolition of sensation and muscular movement. A distinct interval elapses before the next symptom appears, which is the invasion of the sympathetic system, and is shown by the gradual abolition of respiration. Following on this comes the abolition of the functions of the heart.

This view of the independence of the sympathetic system is at variance with the accepted view that the sympathetic system is but an outgrowth from the cerebro-spinal. The evidence from the latter view is based entirely on the histological examination of the embryo. Sufficient account may not have been taken in the interpretation of the observation of the effect of condensation where the development of the organs may not have been sufficiently distinctive and separate to give a clear conception of their relationship. A careful study of the functions and of the peculiarities of the two systems as above outlined certainly raises a strong doubt as to the reliability of the embryological view.

Visceroptosis. *See* Gastroptosis.

Vision, The Field of.—For clinical purposes the field of vision is investigated by the separate examination of each eye. Such examination may be carried out by the following methods:—

I. For rapidly testing the periphery of the visual field the fingers of the examiner are used as the test-object. The patient is placed with his back toward the light, while the examiner, standing from one to two feet directly in front of him, carries out the test. If the patient's right eye is under examination, he is asked to cover the left eye, and to do so without either pressing upon the covered eye-ball or interfering with the vision of the other eye. The examiner, having closed his own right, fixes with his left eye the right eye of the patient, while the patient fixes with his right eye the left of his examiner. In this way continued accuracy of fixation on the part of the patient is ensured, and the examiner is enabled to use the periphery of his own visual field as the standard of comparison.

To complete the test the examiner determines the extreme limits of his own field by carrying his moving finger-tips from beyond these limits inwards, in the various meridians, and always in a vertical plane, which bisects the common line of fixation. In each of the principal meridians the presence, or absence, of coincidence in the extent of peripheral vision is ascertained by asking the patient when he first sees the finger-tips. In this way the presence of a defect in the periphery of the field of vision may be rapidly ascertained, but the extent and nature of such defect can only be determined with accuracy by means of the perimeter.

II. The perimeter is an instrument with which the field of vision may be examined throughout, that is to say, both as to its periphery, its centre, and the whole intervening area. The instrument consists essentially of a graduated arc along which the test-object is carried. The arc is capable of rotation through all the meridians. By the use of an adjustable chin rest the patient's eye under examination is maintained in position at the centre of the circle of which the graduated arc forms a part. The fixation object is attached to the pivot on which the arc revolves. As each meridian is examined the position of the test-object is marked upon the chart which is attached to the back of the instrument.

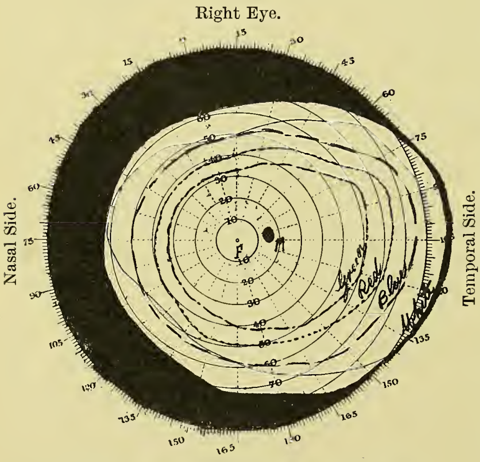


Chart 1.—Test object 20 sq. mm. After Baas. *F*=Fixation point; *M*=Mariotte's blind spot.

Each chart represents the interior of a hemisphere drawn on the flat. The radiating lines show the meridians in which the examination may be carried out, while the concentric circular lines, which are numbered in degrees from the centre outwards, show the extent or limit of the field in any particular direction. An irregularly oval line, which is traced over the chart, shows the normal average boundary line of the field of vision. The preceding complete chart shows the field of vision for white and also for colours in the normal eye.

III. The examination of the visual field, according to Bjerrum's method, with small white test-objects, is carried out in the following way:—The apparatus consists of a large vertical screen made of black velvet, of two metres' diameter, and marked out with fine black cord in concentric and radiating lines. The concentric lines represent at regular intervals the distance in millimetres from the centre to the margin of the screen. The radiating lines mark the various meridians. The fixation object is usually placed at the centre of the screen, but may be removed to either margin if a more extended area is required. The test-objects, which are white, vary in diameter from 1 to 20 mm., those in most common use being from three to six. A long rod covered with the same material with which the screen is made, and supplied with a small spring-catch at its extremity—the "carrier"—is used for moving the test-object about over the screen.

The patient is placed at one or two metres from the centre of the screen, according to circumstances, and is supplied with a chin-rest.

The result of the examination is first marked out on the screen with black pins, and afterwards transferred to a chart upon which there has been previously recorded the results of the ordinary perimetric examination.

The transference of the field from screen to chart is most conveniently carried out by reference to a prepared table of equivalents. This table gives in degrees and minutes the angular separation from the centre of each concentric arc marked on the screen, or of the fractions of a metre as in the table here given from Meisling's paper in the *Annales d'oculistique*, December 1900.

	Distance from Eye	
Metre.	Two Metres.	One Metre.
$\frac{1}{8}$	3° 34′	7° 7′
$\frac{2}{8}$	7° 7′	14° 2′
$\frac{3}{8}$	10° 37′	20° 33′
$\frac{4}{8}$	14° 2′	26° 34′
$\frac{5}{8}$	17° 21′	32°
$\frac{6}{8}$	20° 33′	36° 52′
$\frac{7}{8}$	23° 38′	41° 11′
$\frac{8}{8}$	26° 34′	45°

The carrying out of this test also entails careful attention to the following points:—

1. Careful correction of refraction.
2. An equal and constant illumination of the screen.
3. Accuracy of fixation on the part of the patient.
4. The tendency to rapid retinal exhaustion from continued fixation, which can only be combatted by frequently repeated intervals of rest.

In the normal eye the visual acuity, which is highest at the macula lutea, rapidly falls as we pass towards the periphery of the retina. Thus when the field is tested by Bjerrum's method at two metres' distance, a test-object of 18 mm. diameter, which subtends a visual angle of $\frac{1}{2}$° 1′, gives the field of vision as with the ordinary perimeter. When a smaller test-object is used the normal field becomes reduced in extent accordingly. As can be seen from the chart (No. 2) in which the ordinary perimetric field is shaded grey, while the central part, left white, represents the area responding to the smaller test-object. The chart also shows how the blind spot of Mariotte increases in diameter as the test-object is reduced in size.

The blind spot is surrounded by a zone of retina of relatively reduced visual power, and which fails to respond to the smaller test-objects. The irregularity of outline of the blind spot is due to the large vessels passing over it (see Chart 2).

The clinical importance of morbid changes in the field of vision arises from the fact that certain forms of defect are characteristic of distinct types of disease.

Transitory peripheral limitation of the field of vision is met with in hysteria (see Chart 3).

In this condition the results of different examinations may vary widely.

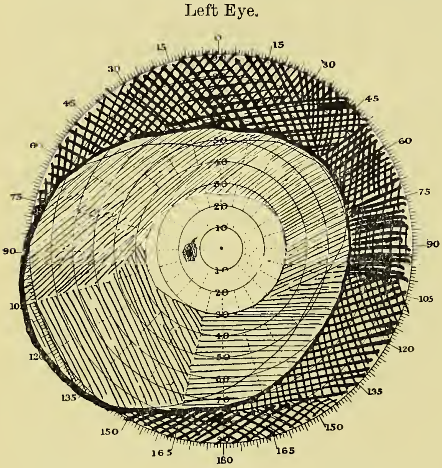


CHART 2.—Normal field for white by Bjerrum's method $\left(\text{Test}\left\{\begin{matrix}\frac{20}{300}\\ \frac{3}{2000}\end{matrix}\right.\right)$.

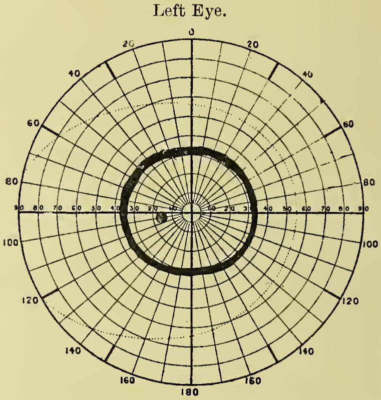


CHART 3.—Peripheral limitation of the field as found in hysteria.

If a prolonged examination of the field be carried out, it is found that increased restriction can be demonstrated as the duration of the examination extends. Further, if the results of examinations in subdued light and in bright light be compared, it is found that the field is more extensive in subdued light. This last point may easily be tested, and is comparatively of constant occurrence.

All the more typical points with regard to the field in this condition depend upon the rapidity with which exhaustion supervenes when sustained functional activity is demanded. Since, however, the hysterical state may coexist with more grave nervous or other disease, further investigation is always necessary. Central vision often remains unaffected, but may also become deteriorated. Lead-poisoning occasionally produces a disturbance of vision similar to that met with in hysteria, though not with the same inconstancy of symptoms. In acute syphilitic choroiditis the field of vision, as well as the visual acuity, are much reduced when examined in subdued light as compared to bright light. This forms a marked contrast to hysteria, and results from the presence of night-blindness in this condition. In the forms of choroiditis, where patches of degeneration occur at various parts of the fundus oculi, corresponding scotomata are found in the field. In some cases secondary optic atrophy plays a prominent part in causing loss of sight. As the ophthalmoscopic signs are sufficient in these cases for diagnosis, it would be of little use to say anything further as to the field of vision in this connection.

Retinitis pigmentosa occurs in both eyes, and is usually associated with night-blindness and concentric limitation of the field. The field may present the peculiarity of a ring-shaped scotomata. Central vision is not, as a rule, full, although often sufficient for reading. The prognosis is unfavourable, inasmuch as no treatment is of any avail, and while the condition may remain stationary for a long time it tends to become worse (see Chart 4).

Any injury to the eye such as might produce commotio retinæ, or hæmorrhage into the retina or vitreous, will cause loss of the field corresponding to the site of lesion. The prognosis is, on the whole, good in these cases, though serious secondary effects may follow. *Detachment of retina* causes loss of vision usually in the form of a sector-shaped peripheral encroachment, often with a history of sudden onset (see Chart 5). The prognosis is bad in detachment of retina, as it often extends and seldom recovers.

Right Eye.

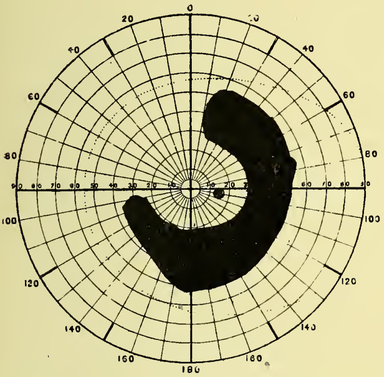


CHART 4.—Partial ring scotoma from a case of retinitis pigmentosa.

Right Eye.

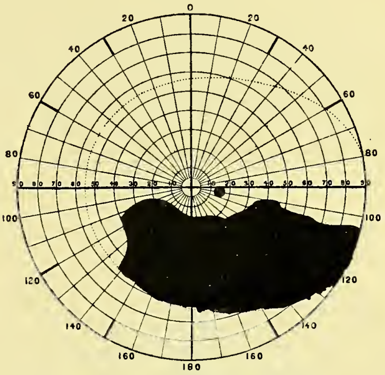


CHART 5.—Detachment of retina.

Central amblyopia is met with in a variety of conditions affecting the retina, choroid, and optic nerve. Central choroiditis can be recognised by means of the ophthalmoscope (see Chart 6). Scotomatous amblyopia following exposure of the retina to direct sunlight, and sometimes caused by electric light, may be recognised from the history of the case and the mode of onset.

Right Eye.

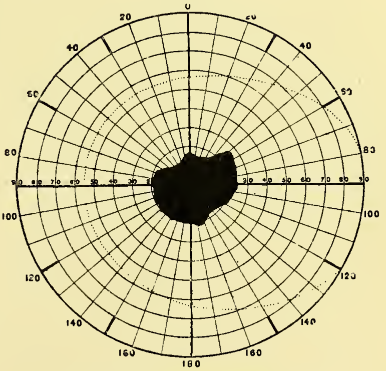
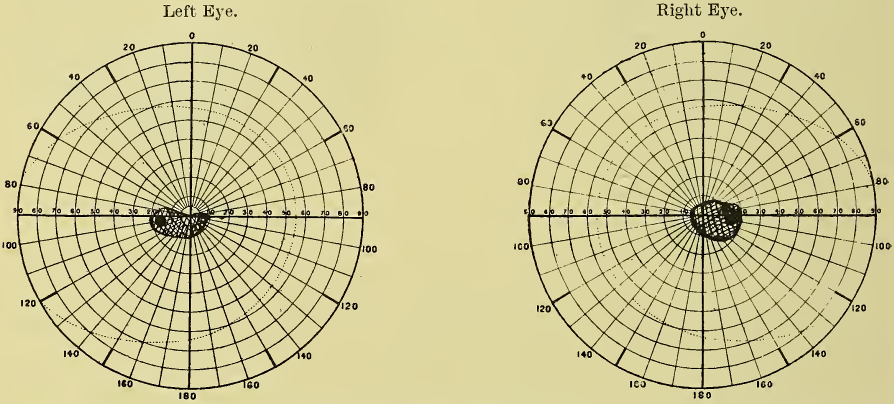


CHART 6.—Central choroiditis.

Simple optic atrophy, with central scotoma, is often met with, and central scotoma is also, although very infrequently, found in cases of glaucoma. Apart from these conditions just mentioned the subject of central amblyopia may be generally considered in two divisions or groups of cases—toxic amblyopia and retrobulbar neuritis.

Toxic Amblyopia.—Under this heading are considered these cases of central amblyopia which are of gradual onset, affecting both eyes usually in the same way, and much to the same extent. The absorption of poisonous drugs, usually extending over a prolonged period of time, is the cause in all cases. The well-known tobacco amblyopia is the most common type, but other poisons are known to produce a similar condition. Bisulphate of carbon, alcohol, iodoform, filix mas, quinine, and cocaine may be mentioned as examples. Tobacco amblyopia is most frequent in men over forty years of age. It is common to find visual acuity considerably reduced. Usually it is less than one-third of normal vision. The light-sense is always markedly affected, so that the power of distinguishing degrees of illumination is much reduced. Thus, if Bjerrum's types for testing the "light difference" are used this defect can be readily demonstrated. The field is of normal extent, and if tested with the usual large-sized white test-object, shows no change throughout. When the test is made with colour (red or green) a colour scotoma is found in each eye, extending from the blind spot, which it includes, to the fixation point, which it often also includes. The scotoma is oval, having its long axis horizontal, and occupies for the most part a paracentral position. It can be demonstrated for white if a sufficiently small test-object is used. It is always negative, that is to say, the patient is not conscious of it as a blind spot in the field (see Charts 7). The prognosis is always good, provided the patient gives up the use of tobacco, and recovery may even take place with the continued use of tobacco in reduced amount. Vision usually begins to improve about one month after the use of tobacco has been stopped, and complete recovery follows in three months or more.



Charts 7.—These charts are from a case of well-marked tobacco amblyopia. The scotoma is for colour and also for Bjerrum's small white object test.

Retrobulbar Neuritis.—Under this heading come conditions of the optic nerve, which, while differing in etiology, have certain common clinical manifestations. The clinical characters of this group are almost entirely subjective, and may be stated as follows:—Rapid failure of vision, usually coming on in one eye. Pain and tenderness in the neighbourhood are often present, and especially on pressing the eyeball backwards into the orbit, and on lateral or vertical movements. Amblyopia is always present in the form of a central or paracentral scotoma, but may vary widely and in any degree from a temporary complete loss of sight on the one hand to almost full vision on the other. Ophthalmoscopic changes are absent as a rule during the early stages. A tendency to recovery is also characteristic. A variety of conditions affecting the optic nerve in its course from the chiasma to the eyeball may bring about the above group of symptoms. It is not, however, possible to discuss these conditions here, but only to mention the more important. Firstly, the nerve may suffer from morbid changes arising in the tissues surrounding it, as orbital cellulitis, periostitis, syphilitic disease of the sphenoid, which is apt to affect both nerves, and tubercle of the chiasma. Secondly, the nerve trunk may be the site of lesion, as in gumma of the nerve.

Disseminated sclerosis may attack the optic nerve, either as part of a general condition manifested in other parts of the nervous system, or as a primary condition of the optic nerve. Rheumatic and gouty conditions, with chill as the exciting cause, account for many cases, while menstrual disturbances are also regarded as a cause. Cases have also occurred in connection with peripheral neuritis. The field of vision is affected in a very similar way to that found in tobacco amblyopia, that is to say, there is a negative colour scotoma in much the same position, and the field is not restricted. The following are the distinguishing points in the field:—The scotoma is either in one eye only, or if in both there is more frequently dissimilarity in form and extent. The scotoma is more apt to extend to the inner side of the fixation point, and tends to be more central and less regular in form than that met with in tobacco cases. Though recovery so often takes place the scotoma may become permanent, and may be associated with loss of peripheral vision. Progressive scotomatous atrophy may follow, or the scotoma may become absolute and remain stationary. The prognosis is on the whole good, though much less favourable than in toxic amblyopia from tobacco (see Chart 8).

Optic neuritis when secondary to increased intra-cranial pressure, as in cerebral meningitis, etc., is almost always bilateral, though one nerve may become affected before the other. During the early stage of this form of neuritis vision is often quite unchanged,—central vision, the field, and the colour-sense remaining normal. After the lapse of some weeks, when the inflammatory exudation begins to be replaced by fibrous tissue, there is often progressive loss of vision. The prognosis is on the whole bad, as post-neuritic atrophy is of frequent occurrence, and in a number of instances leads to complete blindness. In some cases, however, good vision may be permanently retained.

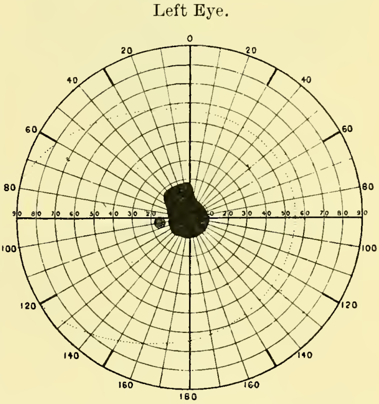


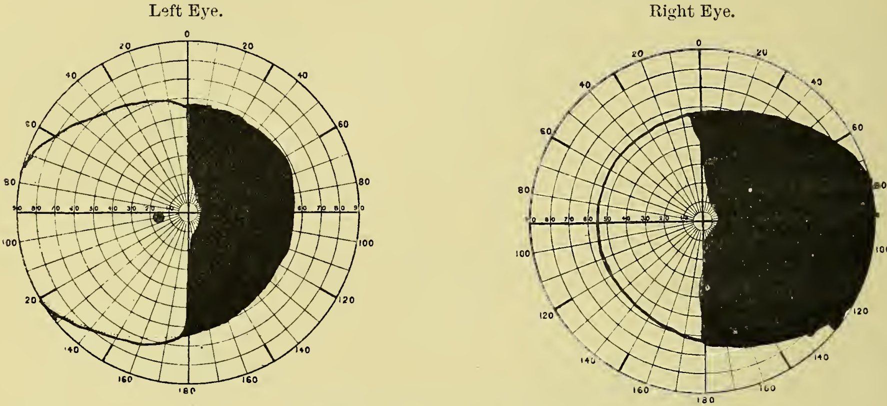
Chart 8.—Absolute scotoma which began with an attack of retrobulbar neuritis and became permanent.

Hemianopia.—The field of vision is here limited in a most remarkable way, and varies according to the form of hemianopia present. The most common form is that known as homonymous hemianopia, which may be right sided or left, complete or partial, relative or absolute. The loss of vision to one side of the fixation point, when both eyes are open, often impresses the patient with the idea that he has lost the sight of one eye. The true state of affairs is at once demonstrated by rapidly taking the field of each eye separately with the fingers. When this is done it is found that in each eye the same side, say the right side, of the field has been obliterated. On more careful examination with the perimeter the complete or partial nature of the case becomes evident. In cases of complete homonymous hemianopia the line of demarcation which separates the blind from the seeing part of the field is very sharply defined. It occupies a generally vertical position, and passes through the whole field at or very near the vertical meridian. The dividing line as a rule deviates towards the blind side close to the fixation point, and thus usually leaves central vision intact.

In incomplete or partial cases the areas of blindness are less extensive than in the complete form. The blind areas usually correspond in position and extent in the field of each eye. Thus homonymous quadrants may be lost.

Homonymous hemianopia is "absolute" in the great majority of cases, that is to say, colour, form, and light senses are all gone. In some cases the condition is of the "relative" type, when the colour sense may alone be lost, while the light sense remains.

The term hemiachromatopsia is applied to cases with marked colour defect. It has been demonstrated by Bjerrum's method that the form sense is also often affected in hemiachromatopsia. It is considered probable that these relative cases are the result of less severe lesions, which only partially interrupt conduction.


Left Eye. Right Eye.

Charts 9.—Homonymous hemianopia.

Homonymous hemianopia is often met in association with hemiplegia, but more frequently occurs apart from that disease. Transient forms may exist in connection with hysteria or migraine, and have been noticed prior to the incidence of cerebral hæmorrhage.

The lesion, of whatever nature, is one which interrupts conduction in the course of one optic tract, and may do so at any point from behind the chiasma to the cortical centre.

The following points may assist in the localisation of the lesion:—

"Wernicke's pupil symptom," or the "hemiopic pupil."—To examine for this symptom the patient should be placed in a darkened room with an ophthalmoscopic lamp behind his head. The eye is then slightly illuminated from the front by throwing reflected light from a concave ophthalmoscopic mirror held well out of focus, while the patient is asked to look across the room in order to avoid accommodation. Finally, with a second mirror held to one side a sharply focussed beam of light is thrown on to the amaurotic half of the retina. If, when this has been done, the pupil fails to react to light thrown upon the blind half of the retina, or does so very little, the symptom is said to be present.

The presence of this symptom is regarded by some excellent authorities as evidence that the lesion involves the optic tract in front of the corpora quadrigemina, thus preventing the effect of light falling upon the amaurotic part of the retina from reaching the third nerve nucleus by way of Meynert's fibres.

If the symptom is not present no conclusions can with safety be based on its absence, because a possible reaction through the normal half of the retina cannot be excluded. It is proper to state that some authorities do not believe that any value can be attached to this symptom.

The presence of word blindness, mind blindness, etc., is suggestive of a cortical lesion, while lesions of the cortex and optic radiations are more likely to produce the incomplete forms of homonymous hemianopia (see Charts 9).

The ophthalmoscopic examination usually shows no change in the disc during the earlier stages, but optic neuritis may be present. In the later stages partial atrophy of the disc is found.

Prognosis is relatively good, as the condition of vision usually remains stationary.

Bitemporal hemianopia.—The true nature of the visual defect is not so obvious in this as in the homonymous form. When the patient comes under observation with both eyes open, the nasal field of each eye extending about sixty degrees to the opposite side gives a binocular field of such lateral extent as might readily escape notice (see Chart 10).

This is more especially the case as the patient is more troubled by his impaired central vision than by the restriction of his field. When the field of vision is examined in each eye separately, it is found to be defective throughout its temporal half in each eye. The dividing line between the normal and the blind part of the field is not so sharply defined, and is less regularly vertical than it is in the homonymous cases. Central vision is usually impaired or lost. Owing to the nature of the lesion the fields are apt at some period in the course of the case to show inequality. Thus the sight of one eye may be lost by the encroachment of the blind area, while the original half-blindness remains in the other. The condition may be relative or absolute, sometimes beginning as relative and later becoming absolute. Cases not infrequently show a tendency to temporary improvement of symptoms. The lesion is almost invariably—to begin with at any rate—one which affects the crossed fibres occupying

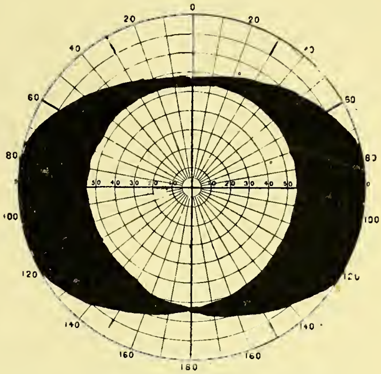
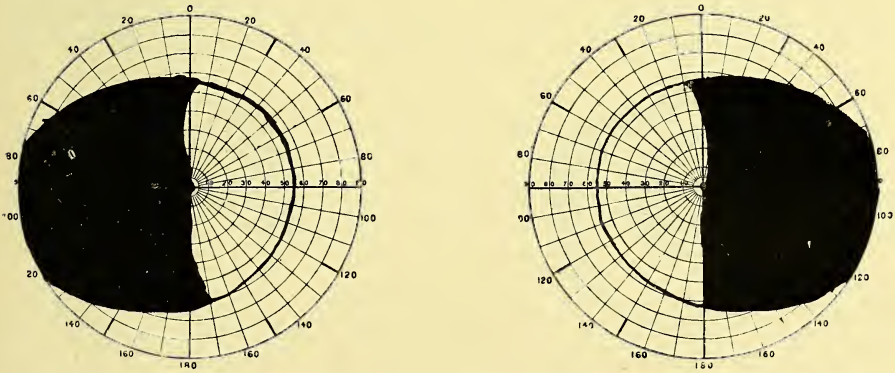


CHART 10.—Showing the binocular field in bitemporal hemianopia.


Left Eye.

Right Eye.

CHARTS 11.—Bitemporal hemianopia.

the central part of the chiasma, and supplying the nasal halves of the retinæ.

Temporal hemianopia is a common early symptom of acromegaly, here resulting from enlargement of the pituitary body. Aneurysm, periostitis, hyperostoses, basal meningitis, and syphilitic gumma are recognised as causes. Symmetrical cortical lesion is very unlikely. The prognosis is bad as compared with the homonymous form, central vision being always impaired, and many cases passing on to complete blindness from atrophy. Occasionally, however, permanent recovery does take place (see Charts 11).

Binasal hemianopia is exceedingly rare. It results from a chiasmal lesion affecting the lateral parts of the chiasma, where the uncrossed fibres pass which supply the temporal halves of the retinæ.

Altitudinal hemianopia also occurs, and is supposed to be most frequently caused by chiasmal lesion, and sometimes by optic neuritis. Cortical lesions may be the cause.

Optic atrophy, apart from those cases of consecutive atrophy already referred to, is met with as a primary condition, and frequently occurs in connection with disease of the central nervous system. In tabes dorsalis atrophy may occur early or late in the course of the disease, and often leads to blindness.

In disseminated sclerosis central scotoma is more common, while the deterioration of vision is less uniformly serious than in tabes. Lateral sclerosis and general paralysis of the insane are also associated with atrophy.

The field of vision for white frequently becomes reduced in a concentric manner, though a more rapid encroachment towards one side more often takes place. The field for white takes no typical form, either with the ordinary perimetric test or with Bjerrum's test. When tested with red or green it is found that the field for colour is reduced out of proportion to that for white.

The condition of colour vision varies considerably in different cases of optic atrophy. When the field for white shows peripheral restriction, and the area over which colours are recognised is much reduced, the prognosis is unfavourable.

Right Eye.

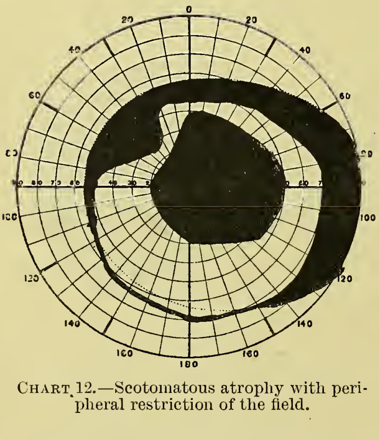


CHART 12.—Scotomatous atrophy with peripheral restriction of the field.

Right Eye.

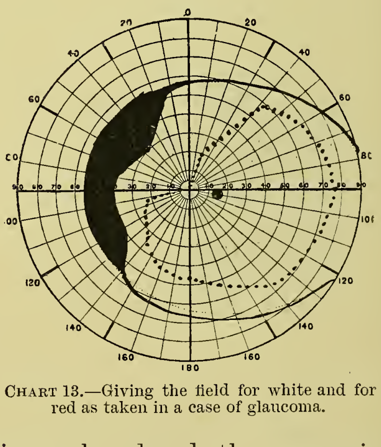


CHART 13.—Giving the field for white and for red as taken in a case of glaucoma.

When central scotoma is present vision is often very much reduced, or central vision lost, yet if the peripheral extent of the field is full, and the colour restriction slight, the prognosis is relatively good, as such a condition may remain in *statu quo* for years. When optic atrophy is not secondary to disease of the choroid or retina, but has begun primarily in the nerve, examination of the light-sense is of value in distinguishing it from chronic simple glaucoma. In optic atrophy the light difference is reduced, while the light minimum is little affected. The reverse condition obtains in glaucoma.

FIELD IN GLAUCOMA.—The form of the field of vision for white, as recorded with the ordinary perimeter, may vary widely, and although there are certain forms of restriction which are more common, it is often necessary to carry the investigation farther by making the test with colours.

In glaucoma it has been shown that while the restriction of the field for colour is greater than that for white, it is on the whole approximate to the normal relationship.

On the other hand, in optic atrophy the colour restriction is relatively greater than for white, often markedly so. A good idea of the types of the field for white, and their relative frequency of occurrence, may be derived from the investigations of Bange (Berry, p. 369), who gives the result of examining over one hundred cases.

1. Defect in the nasal side alone—27 cases.
2. Defect most marked on nasal side—44 cases.
3. Destruction of field, including the centre, and having only a small temporal portion—9 cases.
4. Remaining field in the form of a peripapillary oval—4 cases.
5. A central or paracentral scotoma, with or without slight restriction of nasal margin—4 cases.
6. Concentric restriction—6 cases.
7. Preponderance of defect on temporal side—4 cases.
8. Restriction only upwards—2 cases.

From the above it will be seen that although the form of the field may vary widely, yet in a large proportion of the cases the nasal field is affected most (71 per cent of above).

Difficulties of diagnosis occur chiefly in connection with the simple chronic cases of glaucoma, and as it is in this class of case that the loss of the nasal field is of most frequent occurrence, a preponderance of loss on the nasal periphery of the field may be regarded as the common type.

The chart, taken from an actual case, may prove useful (see Chart 13).

When in glaucoma the field is examined by Bjerrum's method (which has been already outlined), certain interesting and important features appear. The final importance of the result to be gained by this method perhaps demands further corroborative proof, yet its importance is sufficient to justify some notes on it here.

In the December number of the *Annales d'oculistique* for 1900, Mr. Aage A. Meisling of Copenhagen writes on this subject. His paper embodies the results of Bjerrum's former work, together with the additional results of a more recent and extensive investigation of his own on this subject.

The following are the characters of the visual field in glaucoma as quoted from the above-mentioned paper:—

(1) The visual field as taken with the ordinary perimeter does not correspond with that taken by the "small white object" (Bjerrum's) test.

Defects found in the field of vision by examination with the ordinary perimeter are termed "absolute," while those demonstrated by "the small white object" test are termed relative. The relationship of the area over which vision is most fully preserved to that of relative defect is the point of chief characteristic importance.

(2) The area of most acute vision, as also the area of relative defect, are each in contact with the blind spot, or are said to meet at the blind spot.

(3) Scotomata have frequently a paracentral position. They form a characteristic arc round the macular region, either above or below, or both, the concavity being directed towards the fixation point. Scotomata never reach beyond the blind spot toward the temporal side, but may extend to the periphery on the nasal side.

(4) There are some typical fields which are of semilunar form on the temporal side of the blind spot, the blind spot being situated in the concavity of the crescent.

The form of the visual field is stated to be generally characteristic in glaucoma as opposed to optic atrophy, but may be simulated by fields of vision in retrobulbar neuritis, hæmorrhagic papillo-retinitis, and embolism of a branch of the central artery of the retina.

Vital Statistics.

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VITAL statistics is the science of numbers applied to the life-history of communities. Its significance is similar to that of the more recently coined word, Demography—though the latter does not necessarily confine itself strictly to the study of life by statistical means. Another term has been frequently used in recent years—"Vital and Mortal Statistics." The continued use of the word "mortal" in this connection is undesirable and objectionable. The term "vital statistics" is comprehensive and complete, as death is but the last act of life.

Of the problems of life with which the science of vital statistics is concerned, population, births, marriages, sickness, and deaths possess the chief importance; and in the following sketch of the subject I shall concern myself chiefly with these. The subject naturally divides itself into two sections: the sources of information, and the information derived from these sources, and both these will require consideration.

The importance of numerical standards of comparison in science increases with every increase of knowledge. The value of *experience*, founded on an accumulation of individual facts, varies greatly according to the character of the observer. As Dr. Guy has put it, "The *sometimes* of the cautious is the *often* of the sanguine, the *always* of the empiric, and the *never* of the sceptic; while the numbers 1, 10, 100, and 10,000 have but one meaning for all mankind." Hence the importance of an exact numerical statement of facts. The sneering statement that statistics can be made to prove anything can only be made by one ignorant of science. In fact, nothing can be proved without their aid, though they may be so ignorantly or unscrupulously manipulated as to appear to prove what is untrue. Instances of fallacious use of figures will be given as we proceed.

An accurate statement of *population* forms the natural basis of all vital statistics. Thus the comparison of the number of deaths in one with the number of deaths in a second community has no significance unless we know also the number living out of which these deaths occurred. Even then our knowledge would be defective without further particulars as to the proportion in each population living at different ages, and the number dying at the corresponding ages. For other purposes we should require to know the number married and unmarried, the number engaged in different industries, and so on, in order that the influence of marital condition, of occupation, etc. on the prospects of life may be calculated. The first desideratum of accurate vital statistics is a *census enumeration* of the population at such intervals as will not cause the intervening estimates of population to be very wide of the mark. In this country a decennial census is taken, the last occurring in 1901. In the intervals the population of the entire country, and of each town or district, is estimated. Various methods of *estimating the population* have been adopted:—

(1) If a strict record of emigration and immigration be kept then, in a country in which a complete registration of births and deaths is enforced, the population can be easily ascertained by balancing the natural increase by excess of births over deaths, and the increase or decrease due to migration. This is done in New Zealand, but is impracticable in England, as no complete account of migration can be kept.

(2) The increase of inhabited houses in a district being known year by year, the increase of population may be estimated on the assumption that the number of persons per house is the same as at the last census. This may not be strictly accurate. In 1901 it was found that in England and Wales the average number of persons per house was less than in 1891.

(3) It may be assumed that the annual increase during the present decennium will be one-tenth of the increase during the last decennium, 1891-1901. If so, the population, *e.g.*, 1905, is the enumerated population in 1901 *plus* $4\frac{1}{4}$ times the annual increase occurring during 1881-1891. (The *fourth* is required because the census is taken early in April, and the population is estimated to the middle of the year.) This method is fallacious, because it makes no allowance for the steadily increasing numbers who year by year attain marriageable age and become parents. It assumes, in other words, simple interest where compound interest is in operation.

(4) The Registrar-General's method, the one generally adopted, assumes that the same *rate of increase* will hold good as in the preceding intercensal period, *i.e.* that the population increases in geometrical progression, and not in arithmetical progression as under (3). The application of this method will be best understood by an example:—

If the census population of a town is 32,000 in 1891, and 36,000 in 1901, what is the mean population in 1905?

(*a*) *Find the rate of increase in* 1891-1901. If P = population at census 1891 and P^1 = population at census 1901,

and if R = rate of increase of population, then

$$P^1 = P + R^n \text{ in the } n\text{th year.}$$

$$\log. P^1 = \log. P + 10 \log. R.$$

$$\tfrac{1}{10} (\log. P^1 - \log. P) = \log. R.$$

$$\frac{4{\cdot}556303 - 4{\cdot}505150}{10} = {\cdot}0051153 = \log. R.$$

(*b*) *Apply this to the increase in the next* $4\frac{1}{4}$ *years.*

$$\text{Here } P_{1905} = P_{1901} R^{\frac{17}{4}}$$

$$\log. P_{1905} = 4{\cdot}556303 + \frac{17}{4} ({\cdot}0051153)$$

$$= 4{\cdot}578043.$$

By consulting the table of logs. the population corresponding to this number will be found to be 37,848 = population at the middle of 1905.

Estimates made by the last-named "official" method are liable to error even when made for the entire country, and still more when applied to special districts. Thus the decennial rate of increase of the population of England and Wales in 100 years has varied from 15·8 per cent in 1821-31 to 12·4 in 1891-1901. The anomalies are even greater when the official method is applied to great towns. In one decennium such a town may, owing to brisk trade, have a rapid increase of working population with many children, and in the next decennium, in consequence of emigration or transmigration, there may be little or no increase. The declining birth-rate, which is having a greater effect on the number of population than the declining death-rate, is another cause of disturbance which increases the difficulty in forming a correct estimate of population in intercensal periods. A quinquennial census is highly desirable in order to avoid the doubts necessarily associated with estimates of population in the later years of a decennium, and the birth- and death-rates which are based on these estimates.

THE REGISTRATION OF BIRTHS AND DEATHS.—Civil registration of births and deaths began in 1837, but was not compulsory until 1870. It will be going beyond the scope of this article to give details of the enactments as to registration. It suffices to state that it is the duty of the practitioner to give a certificate stating the cause of death of his patient to the best of his knowledge and belief. There is no registration of still-births in this country. Many deaths are registered of which the cause of death is not medically certified, and the value of our national vital statistics is considerably diminished on this account. Much improvement is desirable in the medical certification of causes of death. Every medical student ought to receive instruction on this subject before the completion of his studies. Names of symptoms as dropsy, hæmorrhage, convulsions, and obscure names, as abdominal disease, should be avoided. If the patient has recently suffered from injury, or recently passed through child-birth, or had a specific febrile disease, this must not be omitted from the certificate.

THE REGISTRATION AND NOTIFICATION OF SICKNESS forms another valuable source of information. Various attempts have been made to secure a general registration of disabling sickness, but with only partial success. District and workhouse medical officers appointed since February 1879 are required to furnish the medical officer of health with returns of pauper sickness and deaths. This source of information might, with advantage, be more fully utilised by medical officers of health. Section 29 of the Factory and Workshops Act 1895 requires that every medical practitioner attending on or called in to visit a patient whom he believes to be suffering from lead, phosphorus, or arsenical poisoning, or anthrax, contracted in any factory or workshop, shall send to the chief inspector of factories at the Home Office, London, a notice stating the name and full postal address of the patient, and the disease from which he is suffering—a fee of 2s. 6d. being payable for each notification, and a fine not exceeding 40s. being incurred for failure to notify.

THE COMPULSORY NOTIFICATION OF INFECTIOUS DISEASES is enforced by the Act of 1889, which now applies to the whole country.[1] The list of diseases to be notified is as follows :—

> Small-pox, cholera, diphtheria, membranous croup, erysipelas, the disease known as scarlatina or scarlet fever, and the fevers known by any of the following names : typhus, typhoid, enteric, relapsing, continued, or puerperal, and also any infectious disease to which the Act has been applied by the Local Authority in manner provided by the Act.

It is the duty of the medical practitioner to ascertain whether in his own district such diseases as whooping-cough and measles have been added to the schedule of notifiable diseases. It is the duty of (*a*) the head of the family to which the patient belongs; in his default of (*b*) the nearest relatives in the house; in their default (*c*) of every person in attendance upon the patient; and in default of any such person (*d*) of the occupiers of the building, as soon as they become aware that the patient is suffering from an infectious disease to which this Act applies, to send notice thereof to the medical officer of health of the district. (*e*) The mere formal duty of sending to the medical officer of health a certificate stating the name of the patient, the situation of the building, and the infectious disease from which in his opinion the patient is suffering, is imposed on every medical practitioner attending on, or called in to visit, the patient, on becoming aware that the patient is suffering from an infectious disease to which this Act applies. He is entitled to a fee of 2s. 6d. if the case occurs in his private practice, and of 1s. if the case occurs in his practice as medical officer of any public body or institution. He is subject to a fine not exceeding 40s. if convicted of failure to notify.

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[1] Except London, where similar powers are given by the Public Health (London) Act.

The value of returns of infectious diseases as enabling preventive measures to be taken, is increased by interchange of notification returns of different districts. This is now undertaken weekly for a large number of districts by the Local Government Board, and the Registrar-General publishes quarterly summaries of such returns, as well as weekly returns of infectious diseases for the metropolis.

MARRIAGES are usually stated in proportion to the total population, or the number per 1000 of population; but a more accurate method would be to base the marriage-rate, for comparative purposes, on the number of unmarried persons living at marriageable ages. In England the marriage-rate is always higher in large towns than in rural districts. Thus in 1900 the marriage-rate in London was 17·6 as compared with an average marriage-rate in 1891-95 of 15·2 per 1000 of the estimated population in England and Wales. The higher marriage-rate in towns is chiefly owing to the fact that higher wages and greater scope for remunerative work attract young country people of marriageable ages to towns.

BIRTHS are usually reckoned as a rate per 1000 of population. Clearly, however, if one population had a larger proportion than another of women of child-bearing years this method of comparison would not be free from possible error. Even were the proportion of women of child-bearing ages equal, the comparison might be fallacious if in one population the proportion of single women was much higher than in the other. The possibility of illegitimate births does not materially vitiate this conclusion, as such births do not constitute more than 4 per cent of the total births, and their number is not excessive in the districts in which there is the greatest excess of single women, viz. in districts in which a large number of domestic servants are employed. The only strictly accurate method is to subdivide the births into legitimate and illegitimate, stating the former per 1000 married women of child-bearing years, and the latter per 1000 unmarried women of child-bearing years. I append an example of the relative accuracy of the three methods above indicated:—

[TABLE

Birth-Rate.			
	Per 1000 Inhabitants.	Per 1000 Women aged 15-45 years.	Per 1000 married Women aged 15-45 years.
Kensington	21·8	61·6	215·4
Whitechapel	39·9	172·1	328·3
Percentage excess of birth-rate in Whitechapel over that in Kensington	83%	179%	53%
	A	B	C

Thus, according to the ordinary method (A) of stating the legitimate birth-rate, it is 83 per cent higher in Whitechapel than in Kensington, whereas it is really only 53 per cent higher. Similarly, a statement of the illegitimate birth-rate in the two districts "per 1000 inhabitants" shows an excess of only 6 per cent in Whitechapel, while a statement "per 1000 inhabited unmarried women aged 15-45 years," shows the real excess of 144 per cent. Both in this and other civilised countries there has been in the last twenty-five years a steady decline in the birth-rate. In England the maximum birth-rate was 36·3 per 1000 of population in 1876, and the minimum 29·3 in 1899. This diminution is only caused to a minor degree by postponement of marriage to more mature years and by a larger proportion of celibacy. Nor is there any reasonable ground for the view that a diminished power of either sex to produce children has been produced by alcohol, syphilis, tobacco, or other causes. The main cause of the diminution of the birth-rate is "the deliberate and voluntary avoidance of child-bearing on the part of a steadily increasing number of married persons."

Deaths are calculated in proportion to every 1000 of the population, the unit of time being a year. This unit is preserved even when death-rates for shorter periods, *e.g.* a week, are stated. Thus the death-rates for the thirty-three great towns published weekly in the chief newspapers are *annual death-rates;* they represent the number who would die per 1000 of the population, supposing the same proportion of deaths to population held good throughout the year. The best plan to obtain the weekly annual death-rate is as follows: the correct number of weeks in a year being 52·17747, if the population of a town be 143,956, and the number of deaths in a given week are 35, then the death-rate is 12·687. Thus

$$\frac{143,956}{52·17747}=2758 \qquad \frac{1000}{2758}=0·3625.$$

This is the factor by which the weekly number of deaths must be multiplied

$$35 \times 0·3625 = 12·6875 \text{ or } 12·7.$$

The above is the *crude death-rate.* Various corrections are required, which must now be considered. The most important of these are for public institutions, for visitors, and for age and sex. A public institution, *e.g.* a workhouse, infirmary, or asylum in a given district may consist almost entirely of persons belonging to another district. The rule is to relegate to the district to which they belong all deaths of inmates of an institution, *i.e.* subtract all deaths of outsiders occurring in inside institutions, and add all deaths of inhabitants occurring in outside institutions. The following copy of the official table recently authorised by the Local Government Board for the annual reports of medical officers of health shows the columns giving the necessary corrections:—

TABLE I.—*Vital Statistics of Whole District during 1902 and Previous Years*

Name of District..

Year.	Population estimated to Middle of each Year.	Births.		Total Deaths Registered in the District.				Total Deaths in Public Institutions in the District.	Deaths of Non-residents registered in Public Institutions in the District.	Deaths of Residents registered in Public Institutions beyond the District.	Net Deaths at all Ages belonging to the District.	
				Under 1 Year of Age.		At all Ages.						
		Number.	Rate.[1]	Number.	Rate per 1000 Births registered.	Number.	Rate.[1]				Number.	Rate.[1]
1	2	3	4	5	6	7	8	9	10	11	12	13
1892 *												

[1] Rates in Columns 4, 8, and 13 calculated per 1000 of estimated population.

Note.—The deaths to be included in Column 7 of this table are the whole of those registered during the year as having actually occurred within the district or division. The deaths to be included in Column 12 are the number in Column 7, corrected by the subtraction of the number in Column 10, and the addition of the number in Column 11.

By the term "Non-resident" is meant persons brought into the district on account of sickness or infirmity, and dying in public institutions there; and by the term "Residents" is meant persons who have been taken out of the district on account of sickness or infirmity, and have died in public institutions elsewhere.

The "Public institutions" to be taken into account for the purposes of these tables are those into which persons are habitually received on account of sickness or infirmity, such as hospitals, workhouses and lunatic asylums. A list of the Institutions in respect of the deaths in which corrections have been made should be given in the table below.

Area of District in acres (exclusive of area covered by water). ....

Total population at all ages.................................... } At Census of 1901.
Number of inhabited houses.. }
Average number of persons per house................ }

[See below.

I.	II.	III.
Institutions within the District receiving sick and infirm persons from outside the District.	Institutions outside the District receiving sick and infirm persons from the District.	Other Institutions, the deaths in which have been distributed among the several localities in the District.
Is the Union Workhouse within the District?________________		

* Followed by similar figures for each of the next ten years, and the averages for the ten years.

The population as well as the deaths of these institutions should be excluded, in so far as they are derived from outside the district, in order to make the net death-rate approximately correct.

Theoretically the correction ought to be extended so to apply to visitors who do not die in public institutions. In practice, however, this cannot be effected until a central "clearing-house" is established. The exclusion of deaths of visitors from the district in which they occur is easy; their inclusion in the returns of the district from which they came is more difficult to secure. For the present they should be included in the death-rate of the district in which they occur.

DEATH-RATE ACCORDING TO AGE AND SEX.—To obtain a true conception of the death-rate in a community it is necessary to state the number of deaths in each sex in proportion to the number living at different ages. The importance of this is shown by the following extract from the Registrar-General's report for 1899:—

TABLE I.

ENGLAND AND WALES.—*Deaths to* 1000 *living at each of Twelve Groups of Ages.*

	All Ages.	Aged											
		0–	5–	10–	15–	20–	25–	35–	45–	55–	65–	75–	85 and upwards.
Males .	19·5	60·4	3·8	2·2	3·6	5·3	7·1	12·3	20·0	37·2	69·8	152·6	300·3
Females .	17·3	50·7	3·9	2·3	3·3	4·3	6·1	10·0	15·4	29·8	61·5	142·6	272·0

Thus at ages over 5 and under 45 for males, and under 55 for females, the death-rate is lower than is the total death-rate for all ages. For females at all ages, except from 5 to 15, the death-rate is lower than for males. From the above statement it will be clear that a considerable excess of women (as in a residential district with a large number of domestic servants), or a considerable excess of either sex at the ages of 15 to 45 (as in most large towns), in proportion to the number living at other ages, would produce a lower total or crude death-rate, which does not necessarily imply a more healthy condition than that of another district, which is less favourably constituted so far as the proportion of the sexes and the numbers living at different ages are concerned. By a means of correction now to be described this source of error can be eliminated. The method of obtaining the *factor for correction* can be best understood by an example. The annual death-rate of England and Wales in 1881-90 was 19·15, and the death-rate at each age-group is given in the following table:—

The population of Huddersfield at each of the corresponding age-periods, as given by the census of 1891, is also shown in this table, and in the last column the number of male and female deaths that would occur by applying the death-rates for England and Wales to the population of Huddersfield are shown. The total number of deaths thus calculated is 1572 in a population of 95,420, and the total death-rate = 16·47 per 1000. This is the *standard death-rate, i.e.* the death-rate at all ages, calculated on the hypothesis that the rates at each of twelve age-periods in Huddersfield were the same as in England and Wales during the ten years of the last intercensal period for which the information is available, viz. 19·15 in 1881-90. But the standard death-rate of Huddersfield would have been 19·15, instead of 16·47, were it not for the fact that the distribution of age and sex in the Huddersfield population is more favourable than in the country as a whole. Hence it must be increased in the ratio of 19·15 : 16·47, *i.e.* multiplied by the factor $\frac{19{\cdot}15}{16{\cdot}47} = 1{\cdot}1627$. When the crude or recorded death-rate for 1900 of 16·78 is multiplied by this factor we obtain the *corrected death-rate* of $16{\cdot}78 \times 1{\cdot}1627 = 19{\cdot}51$ per 1000, which is the correct figure to compare with the death-rate of 18·31 for England and Wales in that year. If the death-rate of England and Wales be stated as 1000, then $\frac{1000 \times 19{\cdot}51}{18{\cdot}31} = 1066$, is the *comparative mortality figure* for Huddersfield. Similarly, in the year 1900 the comparative mortality figure of London was 1093, of Croydon 831, of Norwich 919, while that of Liverpool was 1539, of Salford 1541. In all the towns, except Plymouth and Norwich, the corrected death-rate is higher than the crude or recorded death-rate. This implies that in all except these two towns the factor of correction is greater than unity.

Ages.	Mean annual Death-rate in England and Wales 1881-90 per 1000 living at each Group of Ages.		Population of Huddersfield in 1891.		Calculated number of Deaths in Huddersfield.	
	Males.	Females.	Males.	Females.	Males.	Females.
Under 5 . .	61·59	51·95	4,551	4,785	280	249
5 . . .	5·35	5·27	4,691	5,081	25	27
10 . . .	2·96	3·11	5,113	5,165	15	16
15 . . .	4·33	4·42	4,905	5,549	21	25
20 . . .	5·73	5·54	4,541	5,461	26	30
25 . . .	7·78	7·41	7,466	8,834	58	65
35 . . .	12·41	10·61	5,576	6,265	69	66
45 . . .	19·36	15·09	3,944	4,649	76	70
55 . . .	34·69	28·45	2,393	3,017	83	86
65 . . .	70·39	60·36	1,128	1,590	79	96
75 and upwards .	162·62	147·98	250	466	41	69
			44,558	50,862	773	799
Totals			95,420		1572	

This is a convenient point for briefly discussing the RELATIONSHIP BETWEEN THE BIRTH-RATE AND DEATH-RATE. The opinion is commonly held that a high birth-rate is a direct cause of a high death-rate, owing to the great mortality among infants. Table I. shows that the death-rate at ages under five is three times as high as at all ages together, and it is therefore natural to suppose that a high birth-rate, by producing an excessive proportion of persons of tender years, will cause a high general death-rate. This might be so if the birth-rate was to remain high for only five years. But if the high birth-rate continued longer the proportion of the total population at ages of low mortality would be increased, and the general death-rate be lowered. We have already seen that in nearly all the great towns, in which the birth-rate is higher than in rural districts, the age distribution of the population is more favourable to a low death-rate than in rural districts, and their relatively high crude death-rate is made still higher than that of rural districts when the necessary factor of correction is applied.

The INFANTILE MORTALITY should be stated in terms of the infantile population. This is more accurately assumed to be equal to the number of births in the given year than estimated from the number stated to be under one year of age at the last census. The number of deaths under one year of age per 1000 births was 163 for England and Wales in 1899, being lowest in the agricultural counties and highest in mining and manufacturing counties. In the thirty-three great towns it averaged 172 in the year 1900, ranging from 132 in Croydon, Huddersfield, and Halifax, to 236 per 1000 births in Preston. Of 1000 male children born in England and Wales in 1881-90 the number surviving at the age of three months was 921, at the age of six months 889, twelve months 839, while the number of female children surviving one year of 1000 born was 869. In towns a smaller number survive. In the causation of this high infantile mortality ignorance and inexperience on the part of parents play a considerable part, especially as influencing the food and mode of feeding.

The death-rates at other age-groups beyond infancy are given in Table I.

Season influences the death-rate. The third quarter of the year has the lowest death-rate, unless the amount of epidemic diarrhœa has been excessive. In the first quarter of the year the highest death-rate usually occurs. Mild winters and cool summers both lower the mortality. The seasonal incidence of infectious diseases need only be mentioned in passing.

Density of Population has important bearings on the death-rate. Thus the urban districts in 1899 had a death-rate of 19·2, and the rural of 16·3 per 1000 of population. Farr found that the death-rate increased with the density of populations, not in direct proportion, but in proportion to the 6th roots of the contrasted populations. This rule does not now hold generally good. It is only after the density has reached a certain degree of intensity that it begins to exert an appreciable effect. Even then it is what is implied in aggregation, rather than the aggregation itself, that is pernicious. In particular, poverty is usually greater in densely populated districts than elsewhere, with its accompaniments of deficient food and clothing and bad housing. Hence the excess of phthisis in tenemented houses, especially in houses with three rooms or less. I have shown that the true density that should be considered is the number of persons to each room, not the number of persons on a given area ("The Vital Statistics of the Peabody Buildings," *Roy. Statist. Soc.*, Feb. 1891).

Occupation and Mortality.—To obtain correct statistics showing the influence of occupation on vitality one must know the number and age of those engaged in each industry and the corresponding number of deaths. A statement of the mean age at death of those engaged in different occupations would be most fallacious (page 407). The best plan is to restrict the statistics to men aged twenty-five to sixty-five, and calculate for these *death-rates in a standard population,* after the fashion already described (page 404). By this means a "comparative mortality figure" can be obtained. For all males it is 1000, for farmers 563, teachers 603, lawyers 821, doctors 966, butchers 1096, plumbers 1120, brewers 1427, innkeepers 1659, potters 1706, file-makers 1810. Speaking generally, the occupations are most unhealthy in which there is the greatest exposure to dust, to the breathing of foul air, and to excessive indulgence in alcoholic drinks. (For further details see the author's *Elements of Vital Statistics*, page 169 *et seq.*)

Deaths from Various Causes.—These may be stated in proportion to total deaths from all causes, or in terms of the population. The first plan must be adopted only when it is desired to ascertain the proportional share of a given cause of death in the total mortality. In 1899 in England and

Wales the diseases named in the first column of the following table were the most prolific causes of death:—

England and Wales, 1899.—*Deaths from various Causes to 10,000 Deaths from all Causes.*

Bronchitis	880	Influenza	213
Phthisis	729	Whooping-cough	174
Pneumonia	685	Measles	172
Old age	541	Diphtheria	160
Diarrhœa, Dysentery	511	Enteric fever	108
Cancer	452	Scarlet fever	64
Apoplexy	327	Small-pox	3

The diseases in the second column are given in order to indicate their proportional share of the total number of deaths.

The proper plan of stating the death-rate from a given disease is in terms of the population, or better still, subdivided into death-rates from the diseases for different age-groups, as in Table I., if the number of deaths is not too small to admit of this. The importance of stating the death-rate for different age-groups is greatest for such diseases as diarrhœa, whooping-cough, and measles, in which most of the deaths occur at ages under five. In the following table are given the death-rates from the causes of death which are most important, either from their magnitude, or because of their preventible character:—

England and Wales, 1899.—*Death-rate per* 1000 *Persons living.*

Small-pox	0·005	Premature birth	0·58
Measles	0·32	Old age	0·99
Scarlet fever	0·12	Apoplexy	0·60
Influenza	0·39	Convulsions	0·57
Whooping-cough	0·32	Valvular disease of heart	0·38
Diphtheria	0·29	Bronchitis	1·61
Enteric fever	0·20	Pneumonia	1·26
Typhus fever	0·001	Gastro-enteritis	0·61
Cholera	0·04	Bright's disease	0·29
Diarrhœa, Dysentery	0·94	Accidents	0·59
Cancer	0·83	Ill defined and not specified causes	0·73
Phthisis	1·34		
Other tubercular diseases	0·58	All Causes	18·33

Determination of Longevity.—We have hitherto considered only death-rates, *i.e.* the numbers dying each year out of each 1000 of population. The mean duration of life involves another aspect of the same problem. Although nothing is more uncertain than the duration of individual life, the duration of life for the entire community is subject to so little variation that annuities and life assurance can be made the subject of exact calculations. Of the tests employed to measure the duration of human life the most commonly employed is the mean age at death.[1]

Mean age at death $= \frac{\text{sum of ages at death}}{\text{number of deaths}}$. This is a fair method of stating the average longevity of a particular group of persons, if the group is sufficiently large to avoid the possible error caused by paucity of data (page 412). But it would be entirely unsafe to assume that by this means a safe standard of comparison between two groups can be formed. Thus in 1890 it was stated that the mean age at death of workmen was twenty-nine to thirty years, of the well-to-do classes fifty-five to sixty years. This statement throws no light on the relative vitality of the two classes under comparison. The well-to-do classes consist largely of those whose working days are past, and it is as untrustworthy to compare their mean age at death with that of workmen as it would be to base any conclusion on the fact that the mean age at death of bishops is much higher than that of curates. The mean age at death is lowest in countries with a high birth-rate. Hence it would be very fallacious to compare the mean age at death in England and France.

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[1] There is no general agreement as to the exact sense in which the words *average* and *mean* should be used. They are used here interchangeably.

The PROBABLE DURATION OF LIFE (*vie probable*) is a term sometimes employed to denote the age at which any number of children born into the world will be reduced to one-half. In practice it can only be ascertained from a life-table (page 409).

The true mean duration of life, or expectation of life, can only be ascertained from a LIFE TABLE, and this must therefore be briefly described. This is the true *biometer*, of equal importance in all inquiries connected with human life with the barometer or thermometer and similar instruments employed in physical research. The life-table represents "a generation of individuals passing through time." The data required for its construction are the number and ages of the living, and the number and ages of the dying, *i.e.* the data required for ascertaining the death-rate for each year of life. Theoretically the best plan for forming a life-table would be to observe a million children, all born on the same day, through life, entering in a column (headed l_x) the number who remain alive at the end of each successive year, until all have died, and in a second column (headed d_x) the number dying before the completion of each year of life. This method is impracticable, and were it otherwise the experience would be obsolete before it could be utilised. The method employed in constructing the national life-tables for England is, without tracing the history of individuals through life, to assume that the population being given by the census returns, and the death-rates for each age for a given decennium being known, that the same death-rates will continue during the remainder of the lives of the population included in the census returns.

The total mean number living and the total number dying for a given age-period are known. The mean chance (p_x) of living one year during this age-period is found by the fraction :

$$\frac{\text{Population} - \frac{1}{2}\text{ deaths}}{\text{Population} + \frac{1}{2}\text{ deaths}} = p_x.$$

It is usual to start with a million or 100,000 children at birth, and to make a separate table for the proportionate number of males and females at birth. Thus, in Brighton in 1881-90, these were in the proportion of 51,195 and 48,805. Starting with 51,195 male infants at birth, and multiplying this number by ·84608, the probability of surviving for one year, we obtain 51,195 × ·84608 = 43,315. For the second year of life the probability of surviving was ·93398 ; hence the number of survivors is 43,315 × ·93398 = 40,452 ; and so on.

The general arrangement is shown in the following example of a life-table, which only gives the data at or near the two extremes of life, the intermediate figures having been omitted from considerations of space :—

BRIGHTON LIFE-TABLE.—MALES

(Based on the Mortality of the 10 *Years,* 1881-90)

Age. x.	Dying in each Year of Life. d_x.	Born and surviving at each Age. l_x.	Sum of the Number living, or Years of Life lived at each Age, $x+1$, and upwards to the last Age in the Table. Σl_{x+1}.	Mean After-Life Time (Expectation of Life) at each Age. e^0_x.
0	7880	51,195	2,206,174	43·59
1	2863	43,315	2,162,859	50·43
2	996	40,452	2,122,407	52·96
3	733	39,456	2,082,951	53·29
4	440	38,723	2,044,228	53·29
...	...	...	...	...
97	12	29	43	1·60
98	7	17	26	1·53
99	4	10	16	1·48

The 43,315 males surviving to the end of the first year of life out of 51,195 born, will have each lived a complete year in the first year, or among them 43,315 years. Similarly, the 40,452 males will live among them 40,452 further complete years, and so on, until all the males started with become extinct at the age of 105. Evidently, therefore, the total number of complete years lived by the 51,195 males started with at birth will be 43,315 + 40,452 + 39,456 + 38,723 + . . . + 10 + 6 + 4 + 3 + 2 + 1 = 2,206,174 years; this sum being obtained by adding together the numbers living at each age beyond (*i.e.* below on the table) the age in question right down to its last item. This number of years is lived by 51,195 males. Hence the number of complete years lived by, *i.e.* the expectation of life of each male—

$$=\frac{2,206,174}{51,195}=43\cdot09 \text{ years.}$$

This is the *curtate expectation of life.* It deals only with the complete years of life, not taking into account that portion of lifetime lived by each person in the year of his death, which may be assumed to be, on an average, half a year. Hence the *complete expectation of life,* according to the above table, is 43·59 years.

In the following table the expectation of life (complete) for various towns and for England is given:—

Life-Table.—Expectation of Life at Birth

	Males.	Females.
English Life-Table, 1838-54 (Farr)	39·91	41·85
Do. 1871-80 (Ogle)	41·35	44·62
Do. 1881-90 (Tatham)	43·66	47·18
London, 1881-90 (Murphy)	40·66	44·91
Brighton do. (Newsholme)	43·59	49·25
Manchester, City, 1881-90 (Tatham)	34·71	38·44
Glasgow, 1881-90 (Chambers)	35·18	37·70

Formulæ of varying degrees of accuracy have been devised for giving, in the absence of a life-table, an approximation to the expectation of life. WILLICH'S FORMULA is as follows:—If x = expectation of life, and a = present age, then—

$$x=\frac{2}{3}(80-a).$$

Thus, at the age of 50 years the expectation of life, according to this formula, is 20 years. By the English life-table for 1881-90 it was 18·82 for males, and 20·56 for females. **Farr's formula** is based on the birth- and death-rates:—If b = birth-rate, and d = death-rate per unit of population, then—

$$\text{Expectation of life} = \left(\frac{2}{3} \times \frac{1}{d}\right) + \left(\frac{1}{3} \times \frac{1}{b}\right).$$

Thus—

$$b \text{ for England and Wales, 1889-98} = \frac{30 \cdot 3}{1000} = \cdot 0303,$$

and

$$d \quad ,, \quad ,, \quad ,, \quad = \frac{18 \cdot 4}{1000} = \cdot 0184.$$

$$\left(\frac{2}{3} \times \frac{1}{\cdot 0303}\right) + \left(\frac{1}{3} \times \frac{1}{\cdot 0184}\right) = 47 \cdot 2 \text{ years},$$

as compared with the expectation of life for 1881-90, shown in the table on page 409.

In a life-table the number out of which one dies annually,
The mean age at death,
And the expectation of life,
are identical in value

when the whole duration of life, from birth to death, is included in the calculation. This is only true for a stationary or life-table population, in which the number dying is assumed to be regularly replaced by a corresponding number of persons of the same age.

Life Capital.—The life-tables now in use are those based on the experience of 1881-90. The gain in any subsequent year, as in 1900, may be ascertained as follows:—The mean population and the death-rate for each age-group, as 0-5, 5-10, etc., are calculated. Then the mean death-rate of the same community for 1881-90 is applied to this population. By this means the "calculated number" of deaths in 1900 is obtained. The difference between these numbers and the "actual number" obtained from the death-registers gives the gain or loss during the year. Next multiply these differences by the mean expectation of life for the corresponding groups of years. By adding the gains thus ascertained, and subtracting any losses, we obtain the net gain in "life-capital" (Tatham) during the year 1900.

Tests of the Health of a Community.—1. The *general death-rate* is the test most commonly applied and generally trusted. It has its limitations in this respect. It may usually be trusted in comparing a town or district for a single year with preceding years, as the age and sex distribution of a given population only change slowly. But when comparison with other towns or districts is made, the possibility that erroneous conclusions may be drawn becomes considerable. (*a*) Before the death-rates of two districts can be compared, either this comparison must be made by means of death-rates for age-groups (0-5, 5-10 . . . 65-75, etc., etc.), or the factor of correction, the method of obtaining which is described on page 404, must be applied. (*b*) It must be insured that in the two compared districts an equal amount of correction has been made for deaths occurring in public institutions and among visitors (page 402). (*c*) Even when the above precautions are taken it is conceivable that a town with a death-rate of 15 per 1000 may really be as healthy as another with a death-rate of 12 per 1000, though a statistical justification of this statement is a difficult task. Social conditions, quite irrespective of the sanitary condition or the natural salubrity of a district, have an important influence on the death-rate. Poverty, and all that it denotes, necessarily involves a higher death-rate than occurs among the well-to-do. Furthermore, the domestic servants employed by the latter frequently die in districts other than those in which they are employed, without any possibility of the requisite corrections being made.

2. The *zymotic death-rate* is frequently quoted as a test of sanitary condition. This is a death-rate based on the deaths from the "seven chief zymotic diseases"—small-pox, measles, whooping-cough, diphtheria, scarlet fever, fever (chiefly enteric), and diarrhœa. This death-rate should be entirely discarded, the death-rate from each infectious disease being separately stated. A high death-rate from enteric fever would be a much more serious reflection on the health of a town than a high death-rate from whooping-cough.

The death-rate from each of these diseases in London and in England in 1899 was as follows:—

Death-Rate in 1899 *per* 1000 *Living*

	England and Wales.	London.
Small-pox . . .	·005	*Nil*
Measles	·32	·47
Scarlet fever . . .	·12	·08
Diphtheria . . .	·29	·43
Typhus	·001	*Nil*
Enteric fever . . .	·20	·18
Whooping-cough . .	·32	·38
Diarrhœa . . .	·94	·92

A statement of the death-rate from each of these diseases for a series of years is a much more trustworthy test than a similar statement for a single year, in which accidental causes may have caused a temporary increase, or a statement of the average result for a series of years, which tends to conceal the epidemic variations of the disease in question. The danger of such averages has been well exposed by Chadwick in the remark, that "a mean between the condition of Dives and Lazarus tends to make it appear that after all Lazarus has not so much to complain of."

3. The *infantile mortality* (page 405) is a delicate test of mixed sanitary and social conditions, and stress may always be laid on it from these standpoints. The importance of comparing death-rates at other age-groups has already been emphasised.

4. The most delicate and exact method, if all the data are accurate and complete, is to construct a *life-table*, and ascertain the expectation of life in comparison with that of other communities.

The preceding statistical tests of the salubrity of a community, and any others that may be available, should all, when practicable, be utilised; and it should always be remembered that these tests, especially the general death-rate, are most trustworthy when contrasting the experience of a community with its past experience, and least trustworthy when contrasting its experience with that of others, owing to the difficulty in the latter case of ensuring the avoidance of error arising from *non ceteris paribus*.

STATISTICAL FALLACIES.—If "fallacies" be regarded as synonymous with "errors," clearly they may occur at every step. They may be classified as errors of data and errors of methods. The most important *errors of data* are erroneous estimates of population and erroneous returns of deaths, especially in the direction of exclusion of certain deaths (page 402). Death-rates for short periods are relatively untrustworthy. The erroneous use of the mean age at death as a test of longevity has been mentioned (page 407). These are, in part also, *errors of methods*, and numerous mixed examples are given below.

Errors from paucity of data frequently arise (the "fallacy of small numbers"), a too hasty generalisation being the most common fault in medical writings, especially in therapeutics. The degree of approximation to the truth of a varying number of observations is estimated by means of Poisson's formula. If—

μ = total number of cases recorded in two groups.
m = number in one group.
n = number in the other group, so that $\mu = m + n$.

The extent of variation in the proportion of each group to the whole will vary within the proportions represented by—

$$\frac{m}{\mu} + 2\sqrt{\frac{2.m.n}{\mu^3}} \text{ and } \frac{n}{\mu} - 2\sqrt{\frac{2\ m.n}{\mu^3}}.$$

The larger the number of the total observations (μ), the less will be the value of $2\sqrt{\frac{2\ m.n}{\mu^3}}$, and the less will be the limits of error in the simple proportion $\frac{m}{\mu}$.

Thus, of 147 cases of enteric fever 17 died, a fatality of 11·4 per cent. The possible error is determined by the second half of the above formula:—

$$= 2\sqrt{\frac{2 \times 17 \times 130}{147^3}} = 2\sqrt{\frac{4420}{3{,}176{,}523}} = {\cdot}0746,$$

i.e. the possibility of error = ·0746 to unity, or 7·46 per cent. In other words, in a second series of cases of enteric fever under the same conditions as the above, the fatality may vary from 3·94 to 18·86 per cent,—a vague result, which indicates that the first series cannot be regarded as establishing more than a *primâ facie* case in favour of any special method of treatment that may have been adopted.

Non Ceteris Paribus.—The necessity that data to be compared shall be collected on a uniform plan, and be of a strictly comparable nature, is very frequently ignored. The conclusion that the administration of a given antiseptic is a valuable means of treating enteric fever is not demonstrated, by the fact that the fatality in the series of cases thus treated is 7 per cent, while in another series treated without antiseptics it is 14 per cent, unless it is shown that the age and other previous conditions of the patients in the two groups were not widely different, and unless the series are sufficiently long to avoid the fallacy due to paucity of data.

Errors from the Composition of Rates.—If the death-rate of A, having a population of 10,000, is 10 per 1000, and of B, having a population of 20,000, is 15 per 1000, the combined death-rate is not $\frac{10+15}{2} = 12{\cdot}5$. To obtain the correct combined death-rate the number of deaths in A (= 100), and in B (= 300), must first be ascertained, and then the death-rate in a population of 30,000, in which 400 deaths occurred = 13·3 per 1000.

Errors from stating Deaths in Proportion to Total Deaths.—There is nothing erroneous *per se* in stating the proportion of deaths at one age as a ratio of the total deaths at all ages, or the deaths from one cause as a ratio of the total deaths from all causes. It is a useful, and, in fact, the only method practicable, when it is required to give the proportion of one of these to the other. But beyond this such ratios cannot be trusted. For instance, the proportion of fatal accidents among male infants is 12·2, and among female infants 25·1 per cent of the total fatal accidents in the male and female sex respectively. But it would be erroneous if it were concluded from these figures that females are more subject to accidents than male infants. The only conclusion that they justify is that, at higher ages, females are much less subject to fatal accidents than males. In actual fact, for every 1000 infants born, only 2·9 females, as against 3·1 males, die under one year of age as the result of accident.

Again, suppose the case of two towns, A and B. A, with a population of 10,000, has 150 annual deaths, of which 20 are caused by cancer; the general death-rate, therefore, being 15, and the death-rate from cancer 2·0 per 1000, while the deaths from cancer form $\frac{2}{15}$ of the total deaths. B, with the same population as A, has 300 deaths, its death-rate being 30 per 1000, and 40 deaths from cancer, its cancer death-rate being 4·0 per 1000, while the proportion of the deaths from cancer to the total deaths is $\frac{2}{15}$ as before. It is useful to know in regard to each of these individual communities that cancer causes $\frac{2}{15}$ of its total mortality, but no comparison between the two is practicable on this basis. The only proper comparison is between the death-rate from cancer per 1000 of population in A and B, which shows that it is twice as high in B as in A. A still more accurate method is to ascertain the number of deaths from cancer, and the number living at different age-groups, thus avoiding any errors due to variations in age and sex distribution of population.

ERRORS AS TO AVERAGES.—The most common of these results from paucity of data (page 412). Note that the results obtained from an average cannot be applied to a particular case. The mean duration or expectation of life obtained from a life-table expresses, with almost mathematical certainty, the number of years of life of the members of a community *taken one with another*, but is often not accurate when applied to a single individual.

In *army statistics* errors have arisen by failure to comprehend what is meant by the *average strength* of a force. The statistics must comprise the lives of a given number of persons, as well as the deaths occurring among them, *for an entire year*, or allowance must be made in this respect when required.

Hospital statistics for similar reasons are frequently fallacious. Thus death-rates have been frequently given per 100 occupied beds, which are most misleading, as the frequency of succession of patients, as well as the nature of the patients' complaints, will vary greatly in different hospitals. The only proper method of stating hospital death-rates is on the basis of the aggregate annual number of cases treated to a termination. The cases should be further subdivided according to age, and sex, and disease.

Average death-rates from epidemic diseases when used to compare one community with another may give rise to erroneous conclusions. This is inseparable from the nature of such diseases. During the period under comparison one town may happen to have had, say, three epidemics, and the other four; and possibly, if two or three additional years had been added to the series, the place of the two towns would have been reversed as regards their average death-rate from the disease in question. The proper plan is to give the death-rates from the epidemic disease for every year recorded, to draw a curve of these death-rates for the two towns on the same scale, and to compare the height, the variations of height, and the trend of the curve in each instance.

Vitreous Humour, Diseases of.

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Congenital Abnormalities.—The vitreous humour is developed from mesoblastic tissue, which passes into the eye through an opening in the secondary optic vesicle known as the fœtal cleft.

It is seen microscopically in the fœtus, to be traversed throughout by a dense network of exceedingly fine branching fibrils which have granules attached to them, mostly at the points where they divide. These granules stain with nuclear stains, but are several times smaller than the nucleus of any cell. Before birth this network of fibrils becomes much spaced out, a great number of them disappear together with the granules. It is the persistence of some of the granules on detached fibrils which give rise to the opacities which are seen enoptically, and known as *muscæ volitantes.* These are of such common occurrence that they may be regarded as a physiological condition.

By looking at a white surface, such as a cloud or a white sheet of paper, through a stenopæic aperture they can be best brought into view, and appear as one or more branching delicate lines of opacity with clear round dots on them; they slowly float in front of the eye.

Some people discover their presence accidentally, and then, by concentrating their attention on them, and daily watching their movements, become much alarmed. Short-sighted people and those who suffer from dyspeptic troubles are the class of patients who most frequently complain of them. They have to be diagnosed from floating opacities in the vitreous of pathological formation, which, unlike the muscæ volitantes, can generally be detected by the surgeon on careful examination with the ophthalmoscope. Patients who have discovered their presence should be told that they are of no importance, and encouraged to try and forget them.

In the fœtal eye the vitreous humour is a vascular structure. An artery passes through the centre of it, starting from the central artery of the optic nerve and proceeding to the back of the lens, where it breaks up into branches which encircle the lens in a fibro-vascular sheath. This central artery of the vitreous lies in a canal bounded by a hyaline membrane, and in the vicinity of the optic nerve is surrounded by a cellular lymphatic sheath.

Before birth this artery and its cellular sheath disappear. Various abnormalities may result from their persistence. The artery may remain throughout its whole length, or for a portion only of its extent, either patent and carrying blood, or reduced to a fibrous cord.

When a fibrous tag alone remains persistent, attached either to the optic disc or the back of the lens, it will sometimes be seen, with the ophthalmoscope, to lash about on movements of the eye in an undulatory way, resembling closely the movements of a worm. Indeed, these persistent tags of the central hyaloid artery have sometimes been mistaken for filaria in the eye.

A portion of the cellular lymphatic sheath which surrounds the artery near the optic disc will sometimes alone persist, the artery having completely disappeared. A white membrane is then seen lying on the surface of the disc in front of the retinal vessels.

When the artery remains persistent, patent, and carrying blood, portions of the mesoblastic tissue which should form vitreous humour may develop into fibrous tissue instead, *atypical development of the vitreous.* Irregular greyish masses of fibrous tissue are then seen in the vitreous chamber with blood-vessels coursing through them, and a history of defect of sight in the eye from birth will be obtained.

Degenerations.—The vitreous humour in the fully developed eye consists of a clear fluid, very similar in composition to the aqueous humour, contained in the mesh of a delicate network of transparent tissue which is bounded externally by a hyaline membrane, the hyaloid of the vitreous. There are a few fixed cells in the hyaloid membrane and also some wandering cells in the humour itself.

The hyaloid membrane has firm attachments to the optic disc and to the retina at the ora serrata.

A lymph channel bounded by a hyaloid membrane passes through the centre of the vitreous, *the canal of Cloquet,* in which the central artery, already referred to, at one time lay.

After birth the vitreous humour, being devoid of blood-vessels, is nourished by fluid secreted by the ciliary body. Its normal consistency may become altered by inflammatory or hæmorrhagic effusions into it, by changes in the ciliary body checking its nutrient supply, and by elongation of the eyeball in high myopia. If the network permeating it becomes broken up it is liquefied, and instead of having the usual viscid character, it is thin and watery like the aqueous humour. It may also shrink and contract away from the structures surrounding it, fluid collecting between them and its hyaloid membrane. This condition is termed detachment of the vitreous; posterior detachment when it is separated from the retina, and anterio-lateral detachment when it is separated from the suspensory ligament of the lens.

Liquefaction of the vitreous or *synchisis* can most certainly be detected clinically when associated, as it commonly is, with opacities, the result of past exudate or hæmorrhage into it. These opacities, when the humour is fluid, float rapidly about on movements of the eye. Opacities in the vitreous can be differentiated from opacities in the lens, by continuing to move when the eye has come to rest, and by moving in the opposite direction to the eye; when the eye turns up they move down.

The poor support which fluid vitreous offers to the posterior surface of the lens will sometimes allow the lens and iris to tremble on movement of the eye. Tremulousness of the lens and iris is, however, by no means a certain sign that the vitreous is fluid, it may result from defects in the suspensory ligament, and it is not always present when the vitreous is in this condition.

The tension in eyes with fluid vitreous may be normal, very often it is diminished, and when this is the case the eye is very liable, subsequently, to have detachment of the retina or to shrink.

During operations on the eye the surgeon sometimes becomes painfully aware of the liquefying change which the vitreous has undergone, by seeing it ooze away from the wound he has made as a very pale yellow tinted fluid.

In rare cases where the vitreous is fluid it becomes filled with cholesterine crystals, the appearances then seen ophthalmoscopically are of a most beautiful and striking character. The crystals appear as a number of bright golden particles which float about and sparkle with every movement of the eye. The condition, which is spoken of as *sparkling synchisis,* is mostly met with in elderly people, and though associated in some cases with old choroido-retinitis, it may be present without any defect of vision.

INFLAMMATORY INFILTRATION.—The vitreous humour being a non-vascular structure and containing only a very few cellular elements, can but rarely, if ever, be the seat of a true primary inflammation. The conditions which are commonly spoken of as hyalitis are the result of effusion of inflammatory products into the vitreous from the ciliary body or retina, in cyclitis, retinitis, or choroido-retinitis.

These effusions differ in character in different cases, and may be described as either serous, plastic, or purulent. Clinically they give rise to opacity in the vitreous, cause disturbance of vision, and are associated with symptoms of inflammation of the structure from which they are derived, and which are described elsewhere.

The appearance of the vitreous seen ophthalmoscopically varies with the character of the effusion. When serous, webs and irregular-shaped strands of opacity may be seen, or there may be a general diffuse dust-like haze obscuring all the details of the fundus, and through which the light reflex from the optic disc appears like a full moon in a fog. Such a condition is commonly met with in syphilitic retinitis, whilst either condition may be seen in serous cyclitis or in association with patches of choroido-retinitis.

On subsidence of the active inflammation which gives rise to the serous exudate, the opacities tend to clear up and the vision improves. Some liquefaction of the vitreous and floating opacities frequently remain.

When the effusion into the vitreous is of a more cellular and plastic character, the opacity from the first is more dense and of a yellowish colour. Later it tends to develop into fibrous tissue, by the contraction of which the retina frequently becomes detached, and the root of the iris may be drawn back into the circumlental space so as to deepen the anterior chamber at its periphery.

This is the form of effusion which is met with in connection with the cyclitis and retinitis which occur during epidemic cerebro-spinal meningitis, and also in connection with the meningitis in children, the result of ear disease or syphilis. The yellow reflex which it gives rise to from behind the lens simulates that produced by glioma of the retina, for which indeed the condition has several times been mistaken; it is hence often spoken of as pseudo-glioma, under which name it is more fully dealt with elsewhere.

As the result of septic infection of the eye, either through wounds or pyæmic emboli, septic pus may be effused into the vitreous; when this happens suppurative panophthalmitis, with intense injection, much swelling of surrounding structures, and rapid destruction of the eyeball ensues.

Treatment.—The treatment of inflammatory exudation into the vitreous consists in the administration of such drugs as iodide of potassium and mercury with the object of promoting absorption. In the recent serous cases they certainly seem to do good; their use often has to be continued for some months. In cases of some standing the administration of saline mineral waters may prove beneficial.

In the plastic cases no treatment is of much avail, the eye affected frequently after some time shrinks.

In the suppurative cases enucleation or evisceration of the eye becomes urgently necessary for the relief of pain.

INJURIES.—In injuries of the eye the vitreous humour may become displaced. In concussion injuries, if the suspensory ligament becomes ruptured, the vitreous humour may protrude forwards round the side of the lens, between it and the ciliary body, even into the anterior chamber. In such cases, if an incision be made to remove the lens, some of the vitreous is exceedingly liable to present at, or escape from the wound. In some cases, as the result of wounds or from concussion, the lens may be dislocated right back into the vitreous chamber.

In wounds of the eye, from which the lens has escaped or where it is absent, the vitreous humour may pass forward and acquire an adhesion to the cornea. Such anterior synechiæ of the vitreous humour are met with sometimes after needle operations performed for membranes left after the removal of cataracts. A tag of vitreous humour follows the needle on its withdrawal, and becomes entangled at the point of puncture in the cornea.

A tag of vitreous humour prolapses sometimes through a scleral wound, either one inflicted accidentally, or made by the surgeon, in the operation of scleral puncture. A piece of vitreous humour lying prolapsed through a wound, either corneal or scleral, is liable to form the track along which infective organisms may gain entrance to the eye and give rise to inflammation of the uveal tract or retina. In all operative procedures care should be taken to prevent or remove any prolapses of this character.

When the vitreous humour becomes displaced in the way above mentioned there is always, necessarily, some detachment of its limiting hyaloid membrane from one or more of the structures with which it is normally in contact, aqueous or serous fluid occupying the space left.

If a portion of the vitreous humour escapes from a wound, though the eye may fill out and regain its normal tension, no new formation of vitreous takes place, the space left by that which is lost becomes occupied by serous fluid, or a fluid having the character of the aqueous humour. It is surprising in some cases how large an amount of vitreous may escape and yet the eye regain its normal size and dimensions. Detachment of retina is, however, very liable to occur in eyes where a large amount of normal vitreous has been replaced by fluid.

HÆMORRHAGE.—There are three possible sources from which hæmorrhage into the vitreous may proceed, viz. the blood-vessels of the ciliary body, of the retina, or of the choroid, provided the retina has been ruptured or perforated by a direct wound.

It may result either from injury or disease. In some elderly people with degenerate arteries it occurs after straining efforts, such as those occasioned by constipation. Certain young men are occasionally met with who are peculiarly liable to attacks of recurrent hæmorrhage into the vitreous, and in whom no definite constitutional cause has so far been detected. They are usually also liable to attacks of epistaxis, and some of them have been the descendants of gouty parents. Hæmorrhage into the vitreous is also sometimes met with in patients suffering from diabetes.

The clinical appearances presented by hæmorrhage into the vitreous vary with its amount. It may be so extensive that, on examination with reflected light from the ophthalmoscope mirror, the whole pupillary area appears dark, none of the normal red reflex being obtained. In some cases the dull reddish hue of the blood-clots can be seen by focal illumination, and in some the hæmorrhage is localised so that only a portion of the normal reflex of the fundus is obscured.

Blood effused into the vitreous may become completely absorbed, leaving only a few floating strands of opacity behind, or the clots may form the matrix for bands of fibrous tissue to develop in. These when formed appear ophthalmoscopically as dense, greyish white, branching, striated masses in front of the retinal vessels, and having blood-vessels coursing through them continuous with those of the retina.

What is often spoken of as retinitis proliferans commonly arises in this way, *i.e.* by the organisation of blood-clots and the new formation of fibrous bands in the vitreous chamber. As the fibrous tissue develops it contracts, and being adherent to the retina, drags that structure away from the choroid for a portion of its extent.

It is only very extensive and sudden hæmorrhages from the retinal vessels which have sufficient force to extend from the tissue of the retina and break through the hyaloid membrane into the vitreous.

Sometimes blood from a retinal hæmorrhage will collect beneath the hyaloid membrane of the vitreous, raising it away from the surface of the retina over a circular area, like the skin over a blister. Such a condition is most usually met with in the macular region. By the time the surgeon has the opportunity of examining such hæmorrhages ophthalmoscopically, they have, from the effect of gravity, altered from being perfectly circular to having a straight upper border. These subhyaloid hæmorrhages may completely absorb, leaving only a granular condition or a few white spots in the locality in which they were situated, or they may break or diffuse through the hyaloid membrane, and render the whole vitreous turbid and opaque.

Treatment.—In non-traumatic cases of hæmorrhage into the vitreous any tendency to constipation should first be remedied by the use of saline purgatives. All stooping and straining efforts should be avoided. Iodide of potassium in five-grain doses three times a day is given, partly on account of the gouty tendency of many of these patients, and partly with the hope of promoting absorption of the blood-clots. In the cases where the hæmorrhages are recurrent half-drachm doses of the liquid extract of ergot have been recommended. The periodical withdrawal of blood from the temple by the artificial leech, or by real leeches, might also be tried.

Foreign Bodies.—Any hard substance, provided it is propelled with sufficient force, may penetrate the coats of the eye and become lodged in the vitreous, but by far the commonest foreign bodies to find so situated are fragments of steel. There are specimens in the Moorfields Hospital Museum showing in the vitreous chamber such strange foreign bodies as three eyelashes carried in by a knife, grains of gunpowder, and a tin tack.

Foreign bodies which are loose in the vitreous tend to gravitate to its lowest part, and rest on the non-plicated part of the ciliary body. Occasionally a foreign body may pass right through the vitreous, and escape from the eye by perforating the coats at a point opposite that of entrance. In other cases, when the foreign body is propelled with less force, it may strike the back of the globe, injuring the retina and choroid, and then rebound, ultimately coming to lie in the anterior and lower part of the chamber.

If the point of entrance is so situated that in the passage of the foreign body into the vitreous the lens is uninjured, and if it is not lying too far forwards, it may be possible to see it with the ophthalmoscope. It is only in a few cases of injury, however, in which this can be done; in the majority it is very difficult to be sure, from the patient's history and symptoms alone, if simply a punctured wound of the eye has been received, or a foreign body has entered and remained in. The patient usually volunteers the statement that he does not think there is anything in his eye, because he is unable to feel it,—his idea of a foreign body in the eye being necessarily associated with great discomfort.

Accurate knowledge of the presence or absence of a foreign body in the vitreous chamber, if it be metal, stone, or glass, and of its exact position, can be obtained by the use of the Röntgen rays and Mackenzie Davidson's cross thread localising apparatus,—the measurements afterwards being worked out on a schematic diagram of the eye.

The entrance of a foreign body into the vitreous is attended by a certain amount of inflammation of the structures in its vicinity, varying in character and amount according to the nature of the foreign body and the germs which are carried in with it. This inflammation may be localised, and only sufficient to surround the foreign body with fibrous tissue; on the other hand it may be suppurative in character, and rapidly extend to all the structures of the eye.

Treatment.—In a recent case, or one of only a few weeks' duration, in which a piece of iron has become located in the vitreous, its removal should be attempted by an electro-magnet. In some cases, by approaching the eye close to the conical shaped terminal of a very large and powerful magnet, such as that introduced by Professor Haab, and generally known as the "Giant Magnet," a piece of iron can be drawn out of the eye through its aperture of entrance, or through the suspensory ligament of the lens and pupil into the anterior chamber. From this latter position it can afterwards be extracted, through an incision made with a keratotome, by the hand magnet or by forceps.

In some cases, after the position of a piece of iron in the vitreous has been accurately localised, it can best be removed through a meridional incision in the sclerotic made in its immediate vicinity by the introduction into the vitreous of the terminal of a hand magnet.

A foreign body other than iron which has become lodged in the vitreous can only be removed by grasping it with forceps, a very difficult procedure, but one which is facilitated if the exact position in which it is situated is first determined by the X-rays.

Foreign bodies which can be seen with the ophthalmoscope to have become encapsuled, and which are exciting no irritation, may be left in the eye; such cases should, however, be kept under careful observation for some years.

Eyes in which a foreign body is lodged in the vitreous, and which are the seat of either suppurative inflammation or of an inflammation likely to excite sympathetic ophthalmitis, must be enucleated or excised.

PARASITES.—The parasite which has most frequently been met with in the human vitreous is the Cysticercus cellulosæ. Filaria are also described as having been seen, and one undoubted case of hydatid cyst in the vitreous is on record (Hill Griffith).

In this country cysticerci in the eye are exceedingly rare. The writer has only seen two cases. Hill Griffith in Manchester states that he met with 6 cases out of 180,000 patients. In North Germany and Poland cases of this sort are much commoner, due probably to the large consumption in those parts of uncooked meat.

The Cysticercus cellulosæ is the cystic stage of the Tænia solium, the eggs of which find their way into the stomach either from a worm in the intestinal tract of the patient, or are introduced from without either with food or water. The embryos develop in the stomach from the eggs, and by means of hooklets penetrate its walls and enter the circulation. They are then carried to various parts of the body; if they enter an eye they may leave the circulation, growing into a cysticercus either beneath the retina or in the vitreous. If it starts beneath the retina it raises that membrane up away from the choroid, and later on breaks through it into the vitreous.

The ophthalmoscopic appearance of a cysticercus in the vitreous is that of a bluish grey rounded mass, in which often heaving movements at irregular intervals may be detected. The head may sometimes be seen protruded on the surface of the cyst, and its circle of hooklet and suckers be recognised. When the head is retracted it appears as a white shining spot in the wall. After a cysticercus has existed in the vitreous a short while a fibrous tissue covering forms around it, and it appears as a dense white mass, the diagnosis of which from other conditions may be difficult.

If left, an eye with a cysticercus in it is liable to have attacks of irido-cyclitis and ultimately to shrink. In some cases the parasite has been successfully removed through a meridional incision in the sclerotic.

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Voice.—Normal voice production depends on the following factors:—

1. A healthy condition of the respiratory muscles.

2. A normal capacity of the pharyngeal, oral, and nasal cavities, with good muscular development and action of the various muscles whose action influences the shape of these cavities.

3. Unimpaired functional activity of the nerves and nervous centres which control the muscular movements involved in 1 and 2. All defects in voice production are due to some disturbance in one or more of these factors. In the more important cases of defects in articulation in children all the factors are involved. For purposes of illustration it is advisable to select a type of defective articulation, and we may briefly consider the defect as seen in children when due to neglect of the normal process of respiration with resulting structural defects in the respiratory vocal apparatus.

1. *A Healthy Condition of the Respiratory Muscles.*—Probably the most important cause of voice defects in children is to be found in abnormal respiration. A marked failure to expand the chest properly in ordinary and even in deep respirations is characteristic of these cases. An equally serious defect is present in the expiratory phase of respiration, which is short and uncontrolled. And it is this want of control of the expired airs that is one of the primary defects in defective articulation. The first essential in treatment in these cases, therefore, is the due performance of breathing exercises. The child should be made to lie flat on his back and breathe in and out slowly and deeply for half an hour night and morning, special care being taken with the initial exercises to ensure a proper expansion and slow retraction of the chest. The continuation of these exercises for even a few weeks will effect in most cases a remarkable increase in the respiratory capacity of the child, which will react favourably in voice production.

2. *The Resonating Cavities.*—As a result of long-standing neglect of the normal powers of respiration, *e.g.* in typical mouth-breathers, the shape of the various resonating cavities becomes altered in a manner unfavourable to normal voice production. The most striking alterations are—

(*a*) A narrowing of the nasal cavity. This narrowing takes place on all sides. The palate is abnormally high, and the nasal cavity proper is narrowed by the undue approximation of its osseous walls, and also by a thickening of its lining membrane.

(*b*) Chronic enlargement of the tonsils, with hypersecretion from their surface, and also from the congested pharyngeal mucous membranes.

(*c*) There may be secondary alterations in the aural apparatus, deafness of varying degrees, with indrawn thickened membranes and obstructed Eustachian tubes. When the deafness is pronounced it is an aggravating cause of the voice defect. The treatment of these cases will vary with the degree of the local lesions. Operative measures—removal of tonsils or adenoids or other obstructions in the nose—may be necessary as a preliminary. The subsequent treatment consists in an attempt to restore the unacquired art of normal nasal respiration by the use of exercises such as those already described, and, thereafter, the daily use of vocal exercises conducted under the supervision of a medical man who has special knowledge of the defect and its treatment. In these exercises special attention should be devoted to the particular defects present, *e.g.* if the explosives are specially involved, the exercises should be directed to training the special muscular mechanism involved. In many cases the treatment has to be conducted along lines similar to those laid down for stammerers in vol. xii. Treatment has to be continued for many months.

3. *The Nervous Mechanism involved.*—Defects in voice production due to disturbance of the central or peripheral nervous mechanism are more common in adults than in children. Any conditions which prevent approximation of the cords interfere with normal voice production, *e.g.* paresis of the adductors, and any painful inflammation (laryngitis of different types). But the most striking cause of defective articulation is to be found in hysteria, in which functional aphonia is common.

The treatment of the defect in voice production in these cases should be directed to the general disease, the cure of which will be followed by a return of the voice to its normal.

Vomiting.—*Examination of Vomited Matters.*—In examining vomited matters, the first essential is to filter the vomited matter, and then separately investigate the *solid residua* and *the filtrate.* The main points to be determined are—

(*a*) The reaction of the fluid.

(*b*) The presence of pepsin, or trypsin, or rennic ferments.

(*c*) The presence of bile or blood. (See article "DIGESTION," vol. ii.)

Assistance may be obtained in the microscopic examination by the use of various aniline dyes, which have an affinity for the different types of cells present in the vomit, derived from the mucous membrane of the stomach, œsophagus, pharynx, or mouth. It is important to bear in mind that vomited matters may consist either of substances present in the stomach when vomiting begins, or of substances entering it during the process. The latter includes saliva, bile, pancreatic juice, blood, and sometimes fæces.

The act of vomiting is induced by a contraction of the stomach muscle with relaxation of the cardiac orifice. Along with the contraction of the wall of the stomach there occurs a simultaneous contraction of the diaphragm and muscles of the abdominal wall. The whole of this mechanism is under the control of a vomiting centre, situated in the medulla close to the respiratory centre. This centre is readily excited to action by irritation of various afferent nerves. Of these the most important are—

1. The nerves of the stomach, vagus and sympathetic.
2. The nerves of the liver and gall-ducts, vagus and sympathetic; hence the occurrence of vomiting in cases of hepatic derangement, which may be either primary from a biliary calculus, inflammation, and the like, or secondary to inflammation of the pleural surface of the diaphragm.
3. The nerves of the kidney and bladder. Vomiting is frequent in cases of renal calculus; also in various forms of Bright's disease.
4. Uterine and ovarian nerves. Irritation of these nerves is one of the commonest causes of reflex vomiting.
5. The glosso-pharyngeal nerve to the soft palate, root of the tongue, and the pharynx.

There are a few points of clinical importance *re* vomiting that are liable to be overlooked. In the first place, in children the act of vomiting is frequently the earliest symptoms of an acute infective disorder such as scarlet fever, pneumonic fever, acute tuberculosis, and similar disorders. In such cases the vomiting is merely symptomatic, and calls for no special consideration or treatment. Again, in children, but more especially in adults, vomiting is frequently an important symptom of renal disease, often unsuspected.

The treatment of vomiting is the treatment of the disease causing it.

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I. Injuries of the Vulva.—These occur in three ways: by accident, during sexual intercourse, and during parturition.

Accidental injuries are rare, but may result from a kick, a fall with the legs apart upon such a thing as the back of a chair, or the breaking of a chamber utensil when the patient is sitting upon it. Inasmuch as the vulva is very vascular, hæmorrhage may be very free. Such injuries require to be dealt with on ordinary surgical principles, according to the nature of the case.

Injury during coitus consists mainly in unusual tearing of the hymen. Bleeding from a tear of the hymen itself is always inconsiderable; but if the tear extend beyond the base of attachment of the hymen into the substance of the lateral wall of the vagina, bleeding may be free, and even alarming. Treatment will consist in securing any bleeding vessel and sewing up the tear.

Injury during parturition nearly always consists of a rupture of the perineum; occasionally there may be tearing of the lateral walls of the vagina, extending into the vulva, but then the cause is usually to be found in careless instrumental delivery.

Rupture of the perineum is due to disproportionate size or hardness of the fœtal head; precipitate labour; unskilful use of instruments; or morbid conditions of the perineum, such as undue rigidity or undue softness and friability, such as may result from long-continued pressure of the head. The tear may be partial, involving little more than the lower part of the vagina and the fourchette; or complete, extending through the anal sphincter and up the anterior rectal wall; or it may be of any degree between these extremes. In very rare cases a central rupture has occurred, the anterior part of the perineum remaining intact, while a perforation takes place from the vagina to some place between the fourchette and the anus.

The result of ruptured perineum is, in the first place, a tendency to prolapse of the vaginal walls; and when the tear involves the rectum there is more or less loss of control over the bowel contents.

Treatment.—When a perineum is torn during labour it should be sewn up at once. With due precautions as to cleanliness, union is usually rapid, especially when the tear is due to too rapid delivery. But when it follows a protracted second stage the bruising of the tissues may lead to a failure of union. It is always important that the tear should be repaired on its vaginal as well as on its perineal aspect. If union fails, a secondary perineorrhaphy is required, for a description of which a text-book of gynæcology should be consulted.

II. INFLAMMATION OF THE VULVA.—Vulvitis may be simple, infective, or of the nature of a dermato-neuritis.

Simple vulvitis may be due to want of cleanliness, irritating discharges from the uterus, or excessive intercourse. In children it is said to result from thread-worms. It may also be a part of a trauma of the vulva. The symptoms are heat, pain, and throbbing in the vulva, aggravated by exercise. The vulva is congested, red, and swollen. If due to injury, bruising may be seen. The treatment consists of rest, thorough cleanliness, and fomentations. Intercourse must, of course, be avoided.

Infective vulvitis is nearly always gonorrhœal, and it then forms part of a more general infection affecting the genital tract. The symptoms are as above, with the addition of two important features, namely, a muco-purulent yellow discharge, and scalding pain on micturition. On physical examination the vulva is red, swollen, and bathed in a yellow discharge, the urethral orifice is nearly always reddened, and on pressing along the urethra from within outwards a drop of pus can usually be forced out. The orifices of the Bartholinian ducts are often red and unduly patent. Microscopically the gonococcus can be detected in the secretion, usually in the interior of cast-off epithelial cells. The presence of the gonococcus is the only certain indication that the disease is gonorrhœal; but infection of the urethra and Bartholinian ducts is in itself strong presumptive evidence.

Treatment.—The vulvar affection is, of course, the least important part of an attack of gonorrhœa, and the main purpose of treatment is to reach the cervix and vagina. The best plan is a thorough antiseptic washing of the vagina and cervix with biniodide of mercury (1 in 1000), after which douches of a weaker solution of the same lotion (1 in 3000) should be given twice or three times daily. The exhibition of mercury internally often exerts a very favourable effect on the course of the disease. The urethral condition is best treated by diuretics and copious drinking of milk and barley water; if it remains obstinate a dressed probe soaked in a 2 per cent solution of nitrate of silver may be passed into the urethra. Diet should be light, and stimulants forbidden.

Erysipelas of the vulva usually follows labour, and occasionally injuries of the vulva. It presents the same features as when it affects other parts of the body; but owing to the laxity of the connective tissue of the labia there is always much swelling. The inflammation spreads to adjacent parts, such as the thighs, abdomen, and buttocks. The brunt of the affection commonly falls on the labia minora; for, owing to inadequacy of blood-supply, as the result of compression, they may ulcerate or become gangrenous. Treatment must be carried out on general surgical principles.

Diphtheritic vulvitis is characterised by the formation of a membrane, which is composed of fibrin, and stains typically with Weigert's stain: the Klebs-Loeffler bacillus is found in it. It is important to remember that a membranous vulvitis may be non-diphtheritic; in that case the membrane, in contradistinction to the features above indicated, is composed of necrotic material, in which outlines of cells may still be made out, and containing little or no fibrin. The organism present is usually the streptococcus.

Dermato-neuritis is considered under cutaneous affections.

III. Vascular Disturbances of the Vulva.—Under this heading we have to consider varicocele, hæmatoma, œdema, and gangrene.

Varicocele or varix of the vulva is a condition in which the numerous veins of the labia majora assume a dilated and tortuous character. Very often one side only is affected, and the swelling which results may attain the dimensions of a fist. It is not uncommon to find a moderate degree of varicocele during the later months of pregnancy; but any other source of pressure on the veins in the pelvis may produce it. As a rule the vaginal veins share in the dilatation, and varicose veins may be present also in the thighs and legs. When due to pregnancy, the condition commonly subsides after delivery; but it may persist, and in that case, if treatment by rest in the horizontal position fails to restore the normal condition, it may be necessary to excise the varicocele. The operation is usually attended by free bleeding, but when done with care it gives good results.

Hæmatoma of the vulva is an accident that is apt to occur during labour in a case which has presented a varicocele during pregnancy. It is due to bruising and subcutaneous rupture of one or more veins. The feature of the condition is a rapid swelling, beginning in the labium majus of one side, and enlarging till it may attain the size of a fœtal head. As a rule the hæmorrhage ceases spontaneously by its own pressure; and absorption may then be looked for. It is promoted by rest and gentle elastic pressure applied by means of a thick pad of absorbent wool, kept in place by a spica bandage. If the hæmorrhage threatens to become alarming, as indicated by rapid or continuous increase in size, a free incision should be made, the clots rapidly turned out, and the bleeding points secured.

Œdema of the vulva is due to obstruction of lymphatic vessels. It may occur during pregnancy; and we have seen it follow severe vulvitis, and, in one case, an operation for ruptured perineum. The labia minora and prepuce clitoridis are specially apt to be affected; in other cases the œdema spreads over the labia majora and mons veneris. In extreme cases the swelling may form a mass the size of a fœtal head.

Treatment consists of rest in bed, fomentations, and special attention to the evacuations. If the cause is a pelvic tumour obstructing circulation, the tumour must be removed. Pregnancy may require to be prematurely terminated. In some cases the subsidence of the swelling may be hastened by small punctures with a narrow-bladed scalpel.

Gangrene of the vulva is the result of interference with the blood-supply. As we have said, it is particularly apt to occur in cases of erysipelas; we have seen the labia minora slough off in such a case. It may also result from phagedænic ulceration, when the clitoris chiefly suffers; from injuries during parturition; and as a complication of some exanthemata, such as small-pox, scarlet fever, measles, and typhus.

Treatment.—The parts must be kept clean; boracic fomentations should be applied; pain may be relieved with opium; and the patient's strength must be supported.

IV. CUTANEOUS DISEASES OF THE VULVA.—The vulva is liable to be affected by a number of cutaneous diseases, of which the most important are erythema, eczema, lichen ruber, tuberculosis, syphilis, condylomata, leukoplakia, elephantiasis, vulvitis pruriginosa, and kraurosis.

Erythema is usually a transient condition, but it may assume a more chronic form as the result of irritating discharges and want of cleanliness. In very stout people it may be due to intertrigo, when it becomes worse in hot weather. Treatment consists of rest, cleanliness, and the use of dusting powders, such as oxide of zinc, calomel or bismuth subnitrate, mixed with starch or talc powder.

Eczema presents the same characters as in other parts of the body; the mucous surface is not usually involved, but the cutaneous surface shows the typical papules, which become vesicular and break. The escaping serous fluid forms crusts, and the condition is usually aggravated by scratching, which is almost unavoidable owing to the intense irritation. It may be associated with constitutional conditions, such as rheumatism, gout, and diabetes; in other cases it is kept up, if not caused, by irritating discharges from the uterus, or by leakage of urine, as from weakness of the bladder-sphincter or a vesico-vaginal fistula.

Treatment.—Any constitutional or local causes that may be present should be treated. The importance of avoiding scratching should be insisted upon. In the dry forms a lotion of 2 per cent formalin will be found useful, followed by an ointment such as hydrargyri ammoniatum 1 part in 32 parts of lanolin. In moist forms the crusts should be removed with a strong potash soap, and a dusting powder applied, composed of glutol, 1 part, and talc powder, 7 parts.

Herpes resembles eczema, save that the vesicles are smaller and grouped together. It is apt to come on during pregnancy and at the menstrual periods, and usually runs a short course, if not aggravated by scratching. Local treatment should be carried out on the same lines as for eczema.

Lichen ruber occasionally attacks the vulva; in the course of disappearance it is apt to simulate kraurosis. It usually yields readily to the exhibition of arsenic internally.

Tuberculosis is very rare, and is somewhat difficult to distinguish from syphilitic nodules or ulceration. It may appear in the form of lupus, resembling that seen on the face, in which case it presents one of two forms, being mainly ulcerative or mainly hypertrophic and "tubercular." Histologically such an ulcer is composed of characteristic tubercular granulations, while typical tubercles are scattered through the deeper tissues. Tubercle bacilli may be demonstrated therein. The best treatment is to excise the affected parts.

Syphilis is seen either as a primary sore or chancre, or as mucous plaques and tubercles. In the later stages a condition of leukoplakia may be seen; but it is important to remember that a typical leukoplakia may occur on the vulva quite independently of syphilis, and it may then be the precursor of epithelioma.

Condylomata of the vulva are sometimes syphilitic; but they are also, and indeed more frequently, seen in cases of gonorrhœa where there is no evidence of syphilitic infection. They appear as raised patches with a flattened surface on which red points appear, which may merge into ulcerated patches. The whole vulva may be covered with condylomata, and they may extend backwards and surround the anus. The surface of the vulva is bathed in a muco-purulent discharge. The patient complains of great pain and soreness, which is bad when walking, and which may be even worse when sitting down. This condition yields very rapidly to proper treatment, of which the first and most important principle is cleanliness. Rest should be enjoined as far as possible. The local treatment which we have found the most satisfactory is bathing the vulva several times a day with lotio nigra, and vaginal douching with 1 in 2000 of biniodide of mercury; this is followed by the application of mercurial ointment, and mercuric iodide is administered internally.

Elephantiasis.—This condition is due to chronic inflammation of the lymphatics, with dilatation of their canals, leading to hypertrophy of the cutaneous structures, and a thickened rugose condition of the surface. In the more advanced stages thrombosis occurs in the lymphatic vessels, and later still the glands are affected. The parts principally involved are the labia majora; less frequently the clitoris and labia minora; whilst the affection may spread to the perineum and adjacent parts of the thighs. It is but rarely seen in temperate climates; in the tropics it is more common, and the negro races are the principal sufferers. From rubbing against the thighs and clothes, superficial ulceration is apt to occur. The only effectual treatment is the removal of the mass or masses.

Vulvitis pruriginosa is a dermatitis of the vulva in which the nerve-endings are largely involved, with the result that intense irritation occurs. The skin of the affected parts is red and hot at first; later the surface may become paler and the epithelium appears thickened and sodden; usually marks of scratching are seen. It would appear that in some cases this condition is the precursor of kraurosis. The cause of it is not clear; it is probably due generally to trophic nerve-disturbances. It is doubtful whether it can be brought on by the irritation of excessive secretions, though these may lead to pruritus.

The treatment is similar to that of kraurosis.

Kraurosis vulvæ is an atrophic disease affecting first and principally the labia minora, and spreading thence to the vestibule, clitoris, and labia majora. The surface becomes very tender, and dyspareunia results. Further, the patient complains of unbearable irritation, which may come on at all times of the day, and is worse at night when the patient gets warm in bed. Inspection of the vulva shows that the surface of the affected parts is smooth, shiny, even glazed-looking; by degrees all folds and creases disappear, and the vaginal orifice becomes contracted until it will barely admit the tip of the finger. Here and there, and especially in the neighbourhood of the urethral meatus and in the situation of the hymen, small reddish patches are seen; these are very sensitive to the touch. When the disease is advanced, the labia can no longer be recognised, and the clitoris and its prepuce almost disappear. The disease usually comes on after the age of forty, and is best described as a progressive atrophy of the vestibule and nymphæ.

Microscopically there is seen hypertrophy of the epidermis, and hyaline transformation of the outer portion of the corium, with entire absence of hair-follicles and sebaceous glands. In the sub-epithelial tissue there is sclerosis of elastic and muscular fibres, great development of fibrous tissue, and small cell infiltration, and small localised hæmorrhages occur. The nerve-endings become compressed, and this probably accounts for the great irritation.

Treatment.—In this condition, as in the preceding, temporary relief may be afforded by sedative and cooling applications, such as evaporating lotions, glycerole of belladonna, or opium or cocaine ointment. A useful lotion is one composed of one ounce each of glycerine and dilute acetic acid, with 10 oz. of a 1 in 20 solution of carbolic acid. In more obstinate cases the affected parts may be painted over, under an anæsthetic, with a 20 per cent solution of carbolic acid in glycerine: the resulting sore is treated with some sedative ointment. In very severe and intractable cases the diseased area must be freely excised; the cut margin of the skin is then sutured to the cut edge of the vaginal mucous membrane.

Pruritus vulvæ is a symptom which may be due to a variety of causes. These fall naturally into three groups:—

(i.) Irritating discharges.
(ii.) Diseases of the vulva.
(iii.) Reflex irritation.

Under the first heading are comprised conditions causing profuse leucorrhœa, and irritating conditions of the urine, as in diabetes, cystitis, and vesico-vaginal fistula. In the second group we have the vulvitis and kraurosis already described, as well as infection of the pediculus pubis, and congestion of the vulva due to varicose veins or hyperæmia. The latter is apt to come on during pregnancy, and also during menstruation, in which case the pruritus is periodic. Pruritus is also associated with masturbation; but whether as cause or effect it is not always easy to decide. In the third group we find reflex disturbances arising in the rectum and bladder.

The treatment of pruritus will depend on the causal condition; and this should, therefore, be always carefully inquired into.

V. Cysts and Tumours of the Vulva.—(*a*) *Cysts.*—These are found as mucous and sebaceous cysts; cysts of Bartholin's gland or duct; and hydrocele of the canal of Nuck. Hernia is included here for convenience.

Mucous cysts are found on the inner surface of the labia minora. They are small and uncommon, and are treated by incision or excision.

Sebaceous cysts resemble such cysts in other parts of the body. The small black spot marking the orifice of the duct shows their true character. They are liable to suppurate, and should be treated by excision.

Cysts of the duct of Bartholin's gland are due to occlusion of the orifice of the duct; this is sometimes incomplete, and the swelling then varies in size according to the quantity of fluid present. This fluid is usually viscid, but is sometimes watery. In chronic cases the gland itself is involved in the cyst wall. The patient complains of fulness in the vulva, and pain or discomfort when walking, sitting, or during sexual intercourse. On inspection, a pyriform swelling with apex upwards is found in the lower or posterior portion of the labium majus; and the orifice of the duct is nearly always red and unduly prominent. In cases of gonorrhœal or septic infection the contents of the cyst suppurate, resulting in a *Bartholinian abscess.* This presents the same symptoms and signs as a cyst; but pain is usually more acute, and the skin over it is commonly reddened.

The position of the swelling distinguishes it from a hernia and from a hydrocele of the canal of Nuck, in both of which conditions the swelling starts in, and principally affects, the upper or anterior part of the labium in the neighbourhood of the inguinal canal. The only other condition that can be mistaken for a Bartholinian cyst is hæmatoma of the vulva; this is more diffused, doughy, attended with ecchymosis, and has not the pyriform shape characteristic of the cyst.

Treatment consists in excision of the cyst. Its walls are usually well-defined, and it can generally be enucleated entire from the surrounding structures without difficulty. A few deep sutures should be passed under the bed of the cyst, to check oozing; and the skin-margins should be brought accurately together. An abscess must be similarly dealt with; but the separation of the wall of the abscess is usually more difficult, because it becomes closely incorporated with the parts around it, and it is best to insert a drain for twenty-four hours.

Hydrocele of the canal of Nuck is the result of the persistence of a peritoneal pouch by the side of the round ligament, with subsequent closure of its abdominal end. The cavity becomes distended with fluid and appears as an oblong swelling extending from the inguinal canal towards the labium majus. It is distinguished from a hernia by being irreducible, and by a more or less distinct interval between it and the inguinal ring. It is not, however, always possible to distinguish it from a hydrocele of an old hernial sac.

The treatment is excision.

Hernia appears in the vulva in the inguinal form. When large it may greatly distend the labium majus, entering it from above.

(*b*) *Tumours.*—The following are met with in the vulva: lipoma, fibroma, myxoma, angeioma, papilloma, sarcoma, and carcinoma.

Lipomata arise in the labia majora and sometimes in the mons veneris. They are usually sessile and seldom attain a large size. They can be left alone unless they cause discomfort, and then they should be enucleated.

Fibromata are rare, and seldom large; but occasionally a fibroma may form a large pedunculated tumour, causing dragging pain by its weight. These tumours are easily removed.

Myxomata form soft pedunculated masses, arising generally from the labium majus. The pedicle is nearly always narrow. Sometimes the skin covering them is deeply pigmented. They can be removed if they produce discomfort.

Angeiomata are sometimes seen as nævi, mostly in children: more rarely a plexiform angeioma occurs. A nævus seldom requires to be interfered with; a plexiform angeioma is best treated by electrolysis.

Papillomata or warts are common; the ordinary simple wart may be present, but more often papillomata are associated with irritating discharges in cases of gonorrhœa. They are usually pedunculated, but may be sessile; and a considerable area may be covered by them.

Treatment.—Gonorrhœa, if present, must be energetically treated, and the vulva must be kept scrupulously clean. Considerable improvement may usually be effected by the use of mercurial lotion and ointment; if the papillomata persist they should be snipped off, and their bases touched with nitric acid or solid nitrate of silver.

Sarcoma is only rarely met with in the vulva; and it usually takes the pigmented form (melanoma). As a rule the growth is disseminated over other parts of the body, and the outlook is very unfavourable. A localised solitary sarcoma should be freely removed.

Carcinoma of the vulva generally attacks the clitoris or one of the labia majora, and is of the squamous form (epithelioma). When the clitoris is involved, this structure becomes replaced by a mass which may attain the size of a small egg. The surface is usually ulcerated in parts. On the labia majora carcinoma commences as a wart-like structure, which enlarges rapidly and soon breaks down on the surface, forming an ulcerating mass discharging a fœtid secretion. Carcinoma has been known to arise in a vulva affected with kraurosis, and we have met with an example. The glands in the inguinal region become affected, although they may remain free for a relatively long time. Once they are involved the swelling in the groins rapidly increases and spreads to the interior of the pelvis. When the case is seen early enough free removal of the disease gives a favourable prospect of cure. The vulva should be dissected away at some distance from the growth; and the cut edges of healthy skin can generally be united to each other and to the cut edge of the vaginal mucosa. Any glands that can be felt in the groins should be removed at the same time.

Adeno-carcinoma is rarely seen in the vulva; when present it involves the Bartholinian gland. It grows rapidly and shows a marked tendency to recurrence after removal.

VI. Morbid Conditions of the Clitoris and Hymen.—These can be briefly dealt with. Some of the morbid conditions of the clitoris have been described, such as carcinoma and elephantiasis.

Inflammation of the clitoris may be a part of a general vulvitis; or it may be due to want of cleanliness, leading to accumulation of secretion under the prepuce. This may lead to excoriation and even to adhesion of the glans to the prepuce; and considerable irritation may be set up in consequence. Sometimes the pent-up secretion becomes inspissated and hard, forming a kind of concretion.

Treatment.—When the margins of the prepuce are adherent they should be separated with a probe or director; in old cases some dissection may be required to remove a concretion. Cleanliness will generally accomplish the rest.

The *hymen* is sometimes unusually rigid, leading to difficulty in intercourse; and in rare cases it may remain unruptured and present an obstacle to child-birth, conception having occurred without complete penetration. At other times the hymeneal orifice may be unusually small, or it may present a transverse or longitudinal band, so that there are two orifices. The so-called "imperforate hymen" is really a condition of vaginal atresia; the hymen may usually be distinguished on the under surface of the septum. This is dealt with under "Malformations of the Vagina." A rigid hymen will require incision and stretching to allow of coitus taking place.

Carunculæ hymenales are the remnants of the hymen after intercourse has taken place. After child-birth the hymen becomes further destroyed, its remnants being then known as *carunculæ myrtiformes.* Both kinds of caruncle may become acutely tender and painful, leading to dyspareunia. A number of congested spots resembling small recent bruises or petechial hæmorrhages are then seen. They require to be excised.

Small cysts lined with epithelium have sometimes been found in the tissues of the hymen.

Warts or Verrucæ.

VERRUCA VULGARIS or Common Wart.—Common warts usually occur about the backs of the *hands* and *fingers,* but sometimes also on the palmar aspect. The groove along the side of the nail is a favourite situation. They are more often seen in children, and in them are generally multiple. In adults they are more often single. Common warts are more or less hemispherical in shape, or with a flattened top, especially on the palms. Their surface is irregular, rough, and, when of long standing, more or less dirty in colour. On the *face,* although they begin in the same way, they may become more elevated and wider at the top than at the base. The filiform warts of the *eyelids* and *neck* are well known. On the *scalp* they are digitate or cock's-comb-like. In this situation they may be single and last for years. A more uncommon localisation is the *sole,* giving rise to great pain, and unfitting the sufferer for work. Warts of the *lips* have been described, but in one case exhibited as such the condition was, in my opinion, inflammatory exfoliation of the lips (cheilitis exfoliativa).

They are contagious from person to person, and auto-inoculable.

Common warts are epidermal growths (infectious acanthomata, Unna), with an accompanying elongation of the papillæ.

Epithelioma may occur as a complication, and cutaneous horns sometimes develop from warts. In acanthosis nigricans (keratosis nigricans), they are part of the clinical picture in some of the recorded cases.

Treatment.—"Charms" for the cure of warts are well known to folk-lorists. There is no doubt that warts have disappeared after "incantations." This "suggestion cure" has led to the idea of an ætiological nerve origin as opposed to the microbial view. But warts sometimes go spontaneously.

For warts, various acids, glacial acetic, trichloracetic, nitric, and also a saturated solution of chromic acid in water (this acid may form a dangerous compound with spirit); or alkalies, such as caustic potash, may be used. Care must be taken to prevent these remedies running over on to the sound skin. Slicing the warts away with a scalpel and then touching the exposed parts with pure carbolic acid is another way. In obstinate cases of hard, long-standing warts of the hands curetting answers best. As to the painful plantar wart, Radcliffe-Crocker recommends electrolysis, by means of a stout, curved, flat surgical needle passed through the base. The digitate and filiform warts should be ligatured with fine silk. When radical measures are objected to, a salicylic acid plaster can be used to soften and remove the top layers, and then an aqueous chromic acid solution applied. Dirty and disfiguring applications should be avoided as much as possible for the face.

Among the internal remedies, arsenic and thuja occidentalis may be mentioned. Colrat of Lyons recommended sulphate of magnesia in doses sufficient to ensure two or three motions a day. This plan certainly answers in some cases.

Verrucæ Planæ Juveniles.—This is a variety of wart which deserves separate mention, especially from the clinical point of view. They are usually seen on the backs of the hands and on the face, but they may attack other parts of the body. Individually they are roundish, from a pin-point to a lentil in size, slightly raised above the level of the skin, flat, and from a dull reddish hue to a shade of yellow or brown. They are numerous, in some instances slowly increasing in numbers, in others coming out rapidly in crops. They are sometimes preceded, for some time, by a single flat wart (mother wart).

In the case of a girl, aged 13, the backs of the hands and fingers were thickly covered with small flat warts. They had been present for nearly four years. There was a history of warts in adult members of the family, and latterly a lady friend of the child had also developed a few about the hands.

In contrast with this progressive case, a more acute instance observed by Dr. Chalmers Watson may be briefly referred to. The patient, a boy, aged 13, had numerous flat warts about the face, some distinctly arranged in lines, as is not unusual. They had been present six to eight months, and had increased greatly in number after an attack of influenza. The boy had had warts on his hands for a year or more. The warts disappeared under treatment appropriate to the constipation from which the patient suffered. The case is recorded and illustrated in the *Brit. Jour. of Dermatology*, May 1903.

The small flat wart I have also seen in great numbers on the sides of the face of a man, in whom they appeared to have been spread by shaving.

Verrucæ planæ juveniles could not well be mistaken for lichen planus, especially on the face, where the latter disease is of extremely rare occurrence.

Treatment.—Here, again, sulphate of magnesia should be tried. Arsenic is said to clear them off in a few weeks, and thyroid is also stated to have got rid of them. Locally, radical measures are out of place. Washing with soft soap has been recommended, as also various ointments (salicylic acid, resorcin, and so forth). Wiping the parts over with liq. carbonis deterg., sp. vini rect. āā, is useful. In the case of the adult mentioned above, the warts disappeared after perseveringly applying a saturated solution of salicylic acid in alcohol.

Verrucæ Seniles, Senile Warts, also called Seborrhœic Warts.—These occur about the face, trunk, and arms in elderly and old people. They are usually of finger-nail size, raised, more or less round, greasy, and of a dirty brown or even black hue. On removal of the superficial portions, by scratching with the nail, the elongated papillæ show up beneath. They may be present in great numbers, or only sparsely distributed. Radcliffe-Crocker has seen a copious crop on the chest, associated with acute eczema, in an elderly woman.

In a case of my own, a number of them, the size of lentils, developed about the extensor surfaces of the wrists and lower part of the forearms, in an elderly lady in the course of influenzal patchy pneumonia. The warts could be partially scraped away with the nail. They came out two or three at a time; some had involuted, leaving light sepia pigmentation. She also had two small warts about the right thumb which followed a burn. When I saw the patient there was also post-influenzal desquamation about the hands and feet.

Epithelioma may occur as a complication (see Pernet on "TUMOURS OF THE SKIN," *Encyclopædia Medica,* vol. xii.)

Treatment.—The affection is a trifling one. Soap and water and cleanliness generally are the only things needful. If their removal should be demanded, thorough curetting would be best. Any senile wart showing signs of ulceration and growth should be excised.

VENEREAL WARTS are observed about the genito-anal regions and adjacent parts of thighs in women, and in the neighbourhood of the corona glandis in men. They commence as minute lesions, which increase in size and become tufted and pedunculated. They may become very large and cauliflower-like, with inflammation and a fœtid discharge, causing great inconvenience and pain. These growths are associated with irritating discharges such as occur in gonorrhœa, pregnancy, chancres, etc.

Although experimental inoculation has failed, there is no doubt as to their being contracted as a result of impure intercourse. Diday was of opinion that individuals suffering from them had, or had had, warts about the hands.

In a case of warts about the glans penis, recently under my care, there was a history of their commencing ten days after coitus. The warts were millet-sized and flat, with here and there small tufted ones. On the hands I found two hemp-seed-sized flat warts, which the patient had not noticed.

Treatment.—Cleanliness first, and keeping them dry with boric acid powder may suffice. Dusting with talc containing a little salicylic acid, or with the following:—Pulv. frondum sabinæ, pulv. aluminis, āā 10, pulv. cupri sulph. 1 (Finger of Vienna); or they may be removed when large by means of the galvano-cautery. Finger warns against ligaturing them. In pregnant women they may disappear spontaneously after confinement. Nothing should be done during pregnancy, except in the way of cleanliness. Small warts of the penis can be lightly touched with pure carbolic acid, nitric acid, or acid nitrate of mercury, applied with a wooden match end.

WARTY STREAKS.—This condition comes into the category of *ichthyosis* (*hystrix*) *linearis.*

VERRUGA PERUANA (*verruga,* a wart) is a serious acute infective disease of Peru, with multiple lesions (also called Carrion's disease). In some recorded cases only a few verrugas have occurred, and that some time after leaving infected districts of the Andes (see p. 325).

Water.

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Water, though not strictly speaking a food, is absolutely necessary for the maintenance of life, both of plants and of animals. In the human economy it is required as a solvent and as a diluent. For these purposes only, a very small quantity would suffice, probably two to three pints per person per day. The exigencies of modern civilisation, however, demand a far larger supply. Water is required for the cooking of food, for the cleansing of the person, of the house and its appurtenances, for animals and stable purposes, and for gardens. All these may be considered under the head of water for domestic use. The public authorities require water for cleansing streets, flushing sewers, and extinguishing fires, possibly also for supplying baths and washhouses. These may be considered as municipal purposes. Moreover, in most towns it is found to be to the public advantage to supply water for trade and manufacturing purposes.

The amount of water required daily for domestic use varies considerably. Excluding stable and garden, the amount usually allotted in making estimates is 10 gallons per head per day. Where great economy is used, and where earth-closets are provided, this amount might suffice, but it is less than the estimate made by the late Dr. Parkes, based upon records of the amounts used in various households. The estimate is as under :—

	Gallons daily per person.
Cooking	·7
Fluid as drink (water, tea, coffee, etc.) . .	·3
Ablution, including a daily sponge bath . .	5·0
Share of utensil and house washing . . .	3·0
Share of laundry washing	3·0
Total . .	12·0

Where water-closets are used from two to six gallons more will be required. In a water-closet town, therefore, it would not be safe to provide a supply of less than 20 gallons per head per day for domestic purposes. Water not sufficiently pure for domestic purposes is often available for municipal and manufacturing purposes; where such is not the case it is usual to allow 10 gallons per head per day for each of these uses, hence we may conclude that the amount of water actually required will vary from a minimum of 20 gallons to a maximum of 40 gallons. There are many towns not providing this minimum quantity, but in all such there are periods when the supply is inadequate. In other towns more than this maximum is provided, but in such cases the excess is almost certainly wasted, either on account of defective mains or house fittings, or the carelessness or extravagance of the users.

In many towns an attempt is made to economise the use of water by making the supply "intermittent." In such case the mains are only kept full and under pressure for a few hours daily, when the house cisterns fill and are drawn upon for the remainder of the day. Theoretically this method should be economical, but in actual practice it leads to little if any saving, moreover there are many objections to it. The emptying and filling of the mains and the great variations in pressure often lead to insuction of polluting matters, larger house cisterns than would otherwise be necessary must be provided, again increasing the risk of contamination, larger mains are necessary, as the whole day's supply has to be furnished in a few hours, and, in case of fire, water may not be available.

In rural districts where public supplies are laid on by means of mains the amount of water required is not so great as in towns. Usually when the public supply is first furnished the amount used is astonishingly small, probably due to the continuance of habits of economy acquired when the supply was limited. In time, however, the demand increases, but usually the provision of 50 gallons per day per cottage is found to be abundant.

For many of the purposes for which water is required it is not necessary for it to be "pure." Sea water or an impure river water may be used for sewer flushing, road watering, and other municipal purposes; an impure water may also serve for manufacturing purposes. Even for certain domestic purposes a water not sufficiently pure for drinking and cooking might be tolerated. With a *dual supply* the amount of pure water required would be greatly decreased, and possibly in the future dual supplies may be introduced into towns where the available amount of pure water is limited. In country districts such dual supplies are very commonly met with. The well yields water for certain domestic purposes, whilst a neighbouring stream, ditch, or pond furnishes water for washing and slopping. There is little objection to such an arrangement, but in towns a dual supply would involve a second system of mains and supply-pipes, and if laid on to the houses there would be a constant risk of the impure water being used for the pure. This risk might be reduced to an almost negligible quantity, but it is doubtful whether the health of any community would be benefited by the introduction of say a sewage polluted river water for street watering, clothes washing, etc. At present, however, pure water can in nearly all cases be obtained in sufficient abundance as to render it more economical than a dual supply. In other words, it is cheaper to use pure water for municipal purposes than to lay down a second system to provide an impure water. On the coast several towns have during recent years utilised sea water for road watering and sewer flushing.

The terms *pure* and *impure*, as applied to water, are merely relative. A "pure" water does not occur in nature, water always contains gaseous and solid matters in solution, and dead and living particulate matters in suspension, taken up from the air or from the soil, or from both. What these matters are will be discussed later. All natural waters, therefore, are more or less impure, and when the term "pure" is applied to water we simply mean that the water contains no substances which, either from their quantity or quality, are likely to endanger the health of the persons using it. It is in this sense that the word is used throughout this article. An impure water need not of necessity be actually injurious to health. Water contaminated with sewage matter is often used, even by considerable communities, for long periods without the slightest apparent ill effect, but there is always the risk of such a water becoming infected with the specific organism of enteric fever, and possibly of cholera and other diseases; hence its use is attended with a certain amount of danger, and it does not, therefore, come under the definition of a "pure" water. It is impure and unsafe. The distinction is important, as the lay mind finds it difficult to understand that a water which is being used and does not cause any apparent injurious effects may still be impure.

The nature of the substances found in water will be best understood if *the source from which our supplies are obtained* is briefly considered.

All water is originally derived from the ocean. Roughly speaking, three-fourths of the surface of the globe is covered with water. In tropical regions the water evaporates into the superincumbent air with great rapidity. Anstey calculates that on an average about 700 gallons of water is evaporated every minute from each square mile of ocean surface, and Symons declares that "all the coal which men could dig from the earth in many centuries would not give out enough heat to produce by the evaporation of water the earth's rain-supply for a single year." Winds blowing over a large expanse of ocean, therefore, become laden with moisture, and as soon as a cooling effect is produced by the proximity of land, especially if elevated, rain descends. For these reasons the rainfall is heavier on the western side of the British Islands than on the eastern, and greater in mountainous districts than on plains. The amount of rain which falls is measured by the rain-gauge, and expressed in inches of depth. A rainfall of one inch in depth corresponds to about 4¾ gallons on a square yard, or 22,620 gallons on an acre. Rain as it falls is the purest water which occurs in nature. It contains in each gallon about 8 cubic inches of gases, chiefly nitrogen and oxygen, with a little carbonic acid, and traces of saline matter, common salt, sulphates, etc., together with particles of suspended matter, soot, dust, microbes, etc., all of which have been taken from the air. The water which falls during the first portion of a shower, especially after a drought, is always more impure than that which falls later. As usually collected from the roofs of houses rain water is generally very filthy. Ordure of birds, soot, vegetable débris, etc., accumulate on the tiles or slates and in the spouts during the dry seasons, and are washed into the rain-water receptacle with the first heavy shower. These offensive matters undergo solution and putrefaction, but in some cases an apparently good potable water results. Rain water so collected is, however, unpalatable and unsightly, and too impure for drinking purposes. A much better water can be obtained if a rain-water "separator" is used. By attaching this little apparatus to the down spout the first portion of each shower, that portion which brings with it all the filth, is cast into the drain, whilst the water collected after is passed into the receptacle placed to receive it. It is unfortunate that, in very few instances can enough rain water be collected from a roof to supply the requirements of the house. In summer time many slight showers occur which add little to the store, the water evaporating almost as quickly as it falls. When heavy downpours occur a good deal is wasted, the whole not being collected by the gutters or troughs. The amount which may be collected is from one-half to two-thirds of the rainfall. The area covered by the roof of an average cottage does not amount to more than 35 square yards. With an average rainfall 15 to 18 inches could be collected. This would amount to about 3000 gallons in the year, or 9 gallons per day. To collect this quantity a storage tank of about 1500 gallons' capacity would be required. With a smaller tank water would run to waste in the rainy season, and the accumulation would not suffice to tide over a dry summer. Tanks of brickwork lined with cement, or of slate are the best. Galvanised iron tanks are largely used, but the water drawn therefrom usually contains a trace of zinc, which, however, is apparently harmless. Lead tanks yield a taste of metal to rain water, and as lead is a cumulative poison, this metal is not to be recommended.

Rain water collected from the surface of rocks in mountainous regions forms one of the best sources of supply for large communities. The water may either be collected in natural lakes, as in Loch Katrine, for the supply of Glasgow, or in an artificial reservoir or lake, as at Vyrnwy, Wales, for the supply of Liverpool. If the hills are covered in part with peat the water may become more or less discoloured—" peaty." This peaty matter, unless in excess, is quite harmless, and such water if stored for a length of time in open reservoirs gradually bleaches. A water strongly impregnated with peat is believed to give rise to attacks of diarrhœa, especially amongst those unaccustomed to its use. Quite recently it has been demonstrated that in peat there are acid-producing bacteria capable of giving an acid reaction to the water, and such waters act markedly upon lead, zinc, and iron. In the north of England thousands of cases of "plumbism" have occurred from the use of such waters distributed through leaden pipes. Surface water collected from the surface of moorlands upon which farms are situated is liable to pollution, and should not be used unless stored for a length of time, and finally carefully filtered before being distributed.

When rain falls upon a pervious surface, as of sand, gravel, and chalk, a portion penetrates the soil and accumulates there. It is then known as subsoil or ground water. Beneath the pervious rock there is always, at a greater or lesser depth, a stratum of an impervious character which holds up the water. The surface of this stratum usually sloping, the water generally travels more or less quickly in a given direction towards an outlet into the stream draining that particular area. Where the impervious stratum comes to the surface or outcrops the water will issue forth as a spring. Such spring waters are usually bright and pure on account of the water having travelled slowly, and for a considerable distance through the pores of the pervious rock. This subsoil or ground water is yielded by all shallow wells, and forms a most important and much maligned source of supply. The evil reputation of shallow well water is not due to the character of the subsoil water, but to the unfortunate sites selected for wells, and the unscientific and careless method of construction. The rain falling upon pervious ground, ground more or less cultivated, naturally takes up not only mineral matters from the soil, but also organic matter from manure, decaying vegetation, etc. Fortunately there are found in all fertile soils micro-organisms which rapidly act upon the dissolved organic matter, converting it into harmless carbonates and nitrates, and the natural filtration of a compact soil quickly removes all, or nearly all, suspended matter, including the bacteria. The more compact the soil and the greater the depth of the ground water, the purer is the supply likely to be. In compact sandy gravel, loam, chalk, etc., a pure water may be usually obtained from a properly constructed and situated well if the water level is six feet or more from the surface. In selecting a site for a well the proximity to highly manured ground should be avoided. Cesspools and drains should be as distant as possible, and the well should be on the side of the higher ground-water level. If, for example, the ground water flows from east to west the well should be to the east of the possible sources of pollution, any polluting matter entering the soil will then flow away from the well, whereas if the well is on the west the filth will flow towards the well and possibly contaminate the water. Water entering a well at a less depth than six or eight feet cannot be depended upon as being efficiently filtered or purified, therefore this upper portion should be constructed of impervious material, brickwork set in cement, glazed earthenware tubes, or of iron cylinders, and the top should be so finished off that no surface water can possibly gain access. For this purpose it is desirable that the top of the well should be brought up six to twelve inches above the ground surface and covered with a proper flagstone or iron cover. When the soil is gravelly an Abyssinian tube well may be used. This consists merely of a perforated and pointed steel tube driven into the ground until the point is well below the ground-water level. A pump is then fixed to the projecting tube. If care be taken to puddle well round the upper portion of the tube and to fix it firmly, so that no surface water can travel down the loose soil surrounding it, these tube wells are both economical and satisfactory.

In shallow wells, otherwise properly constructed, polluting matter often enters along the track of the pump pipe. This is, generally, simply put through a hole in the brickwork. The constant shaking loosens the earth along the track of the pipe, and surface water following this line of least resistance trickles into the well. The pipe should either enter the well above the ground surface or have a collar upon it, the collar being embedded in cement between the two layers of brick enclosing the well.

Springs are not generally utilised for large public supplies, as the flow is in most cases too variable, falling off seriously in the late summer just when the demand for water is greatest. They are largely used, however, in rural districts, and if properly protected are, in most cases, very satisfactory sources of supply. The water usually has travelled a considerable distance, percolating horizontally through the subsoil, and has become thoroughly purified and filtered.

The ground around a well or spring should be protected, no manurial matter of any kind being placed thereon, and cattle should not be allowed to gain access to the water, or to trample on the ground around. This protective area need not be more than a few yards in diameter, in the case of a well from which only a small quantity of water is drawn, as when only one or two houses are supplied, but it is useless expecting to obtain a really good water from a well placed in a garden highly manured around or over the surface of the well, yet wells of this character abound.

Water from rivers or streams is very variable in character, consisting usually of an admixture of surface, spring, and subsoil water. During heavy rains the surface water may carry with it impurities from the soil, at other times animals may defile it, drainage from houses or farm-yards may enter it, sewage or sewage effluents or manufacturing refuse may be discharged into it. Vegetable growths occurring in the stream or on the banks decay and give up organic matter to the water. For these reasons the majority of streams are so polluted as not to be available as sources of supply. In hilly and mountainous districts where there is little vegetation and few habitations the streams may yield a wholesome water. Where the flow of water in a river is enormous compared with the volume of polluting matter entering, and the water is impounded in reservoirs for subsidence, and as a reserve to avoid having to take water from the river when rendered turbid by floods, and the clarified water is finally submitted to most careful filtration, a good potable water may possibly be the result. London is supplied in this way, and the evidence of experience is apparently satisfactory. It is quite probable, however, that an impure river water may give rise to a high mortality rate from typhoid fever without causing epidemics. Thus in Newark, Notts, typhoid fever was constantly prevalent when the town was supplied with water from the river Trent. In 1893 a fresh supply was obtained from deep wells in the new red sandstone. The fever almost immediately subsided, and has since only been about one-tenth the previous average. The excessive prevalence of enteric fever in the towns in the Tees valley supplied with water from that river was attributed by Dr Barry, an inspector of the Local Government Board, after a thorough investigation, to the polluted condition of the river water. There is no doubt that a polluted river water during its flow tends to become purified. This so-called "self-purification" is due to the action of air, light, vegetable and animal growths, sedimentation, and possibly other causes, but it is probable that no river in the British Isles is sufficiently long to effect complete purification.

Probably the purest of all waters is derived from deep wells, wells supplying water from a porous stratum lying beneath an impervious formation. Such water has generally travelled a long distance from the outcrop to the point from which it is drawn, and any organic matter originally contained in it has become completely oxidised, and filtration has been practically perfect, far more perfect than any artificial process. Immense stores of the purest water are contained in the chalk, sandstone, and oolites, and smaller quantities in the lias, greensands, Hastings and Thanet sands, and millstone grit. When the outcrop is at a much higher elevation than the ground surface at the site of the well the water may overflow. Such wells are usually called "artesian," from the province of Artois in France where such wells were first found. Such a well recently sunk at Bourn, Lincolnshire, overflows at the rate of about five million gallons per day, and is probably the most prolific underground spring yet tapped in England. It is calculated that the chalk in the Lea valley will yield forty million gallons of water per day in the driest years, and the Kent chalk twenty-seven million gallons. Deep wells are usually bored, and the boring lined with screw-jointed steel tubes. Where water can be obtained from deep subterranean sources there are many advantages besides that of purity. Very little land is required, no compensation water has to be provided, filtration is unnecessary, and protection from pollution is easy. On the other hand, pumping has usually to be resorted to, but with modern machinery this is not a serious item. Deep wells are expensive to construct, hence they are rarely sunk for the supply of single houses or small communities, save in districts where no other source is available. In some cases the well tube is brought above the ground surface and a pump attached. The only possibility of pollution is from perforation of the tube, when subsoil water, which may be impure, may be drawn in. In other cases the tube terminates at the bottom of a well, and this well is liable to all the risks of the ordinary shallow well.

Contaminated waters are often used for lengthened periods without producing any appreciable effect upon the health of the consumers, but it seems quite probable that, in many instances, the system has become accustomed to its use. It is a common experience to find that persons who have previously used a pure water suffer from diarrhœa when they have to drink such a polluted water. In some rural districts where pond water is used the old inhabitants often prefer it to a purer supply, whilst other families moving into the district are so affected by the water that they remove again as early as possible. Sooner or later, however, specific pollution occurs and disease follows.

Diarrhœa is the most common symptom of water poisoning, and may be caused by quite a variety of substances. Finely divided mineral matter may cause the irritation, or an excessive amount of magnesium sulphate or chloride, and possibly other salts. Water impregnated with even a small quantity of sulphuretted hydrogen, or with the gaseous emanations from drains, has often been charged with causing diarrhœa. Water impregnated with decaying vegetable matter or with peat may affect persons unaccustomed to its use. Sewage polluted water has frequently caused outbreaks, often with choleraic symptoms. In Lincoln, in 1891, an epidemic of diarrhœa occurred, limited to persons drinking water from the river Witham. The water was turbid and had an offensive smell when heated, and contained much organic matter. Many other outbreaks of a similar character are recorded. Epidemics of dysentery have been traced to the use of water polluted with decomposing animal matter.

Goitre is believed to be caused by some constituent found in the waters of certain districts, but the evidence with reference to the nature of the goitre-producing substance is very conflicting. The most convincing proof of goitre being produced by the drinking water is the evidence given before a French Commission, to the effect that in the village of Bozel, in 1848, there was a population of 1472, of whom 900 were goitrous, whilst at St. Bon, a neighbouring village with a different water-supply, there was not a single case. When the water from St. Bon was carried to Bozel goitre decreased so rapidly that in 1864 there were only 39 persons affected. Whatever the special constituent, it appears to be most common in the water from the magnesian limestone formation.

Plumbism is frequently caused by the continued use of waters containing lead. This metal is very rarely found as a constituent of natural waters, but many very soft waters act energetically on lead pipes, cisterns, etc. Certain hard waters containing little or no calcium carbonate have also an action upon lead. Water by contact with peat takes up a minute amount of acid, believed to be produced by a micro-organism growing on the peat, and such acid waters have a marked plumbo-solvent action. Plumbism has been very prevalent in the West Riding of Yorkshire. "The amount of lead dissolved depends upon the character of the water, the time during which it is in contact with the metal, the temperature, pressure, and possibly upon other factors of which we as yet know but little. The effects produced by the small amount of lead dissolved are rarely so serious as to cause death, or even the severe colic or paralysis characteristic of lead poisoning (or even the blue line on the gums), and for this reason the injurious results of the long-continued use of waters so polluted are only gradually receiving recognition. Amongst the effects produced are a state of listlessness leading to melancholia, depression, and actual insanity, pallor and debility, constipation and indigestion, paralysis, colic, gout, kidney disease, blindness, etc. Still-births increase, and the children of lead-poisoned parents are rickety and ill-developed."[1] There is no doubt that persons vary in susceptibility to the action of this cumulative poison. One-tenth of a grain per gallon has been known to produce ill effects. An "active" water which has been allowed to stand in lead service-pipes during the night may contain 1½ grains or even more per gallon. By filtering an "active" water through beds of chalk or limestone the acid may be neutralized and its plumbo-solvent action more or less completely destroyed.

Zinc is occasionally found as a natural constituent of water. The soft waters which act upon lead will also dissolve zinc from the surface of galvanised iron. A water may take up as much as 3 or 4 grains of zinc carbonate per gallon by its action on a long galvanised service main. There is reason to believe that the use of such a water may cause obstinate constipation, especially in children, but beyond this no ill effect appears to follow even from its habitual use.

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[1] *Water and Water Supplies*, p. 139. London: Retman, Limited.

Enteric or typhoid fever is undoubtedly due in a large proportion of cases to the use of polluted drinking water. So large a number of outbreaks have been attributed to this cause that it is difficult to make a selection. These outbreaks may be divided into two classes: those in which specific pollution of the water was proved, and those in which this proof was not forthcoming. The latter class is by far the more common. As illustrating the first class the following instances may be cited, as they also show some of the various ways in which a water-supply may become polluted. In 1874 over 2000 cases of enteric fever occurred in Over Darwen (Lancs). It was found that a person suffering from this fever resided in a house, the drain from which was defective at a point where it crossed a leaking water-main. It was demonstrated by experiments that this sewage was sucked into the main freely and regularly. Within a short period of the specific pollution occurring about one-tenth of the population had contracted the disease. In 1882 an epidemic occurred in Bangor, 540 persons out of a population of 10,000 being attacked. It was proved that the stream supplying water to the town had been polluted by the discharges from an enteric fever patient. About this time the filter beds were disturbed by the bursting of a main, and a fortnight afterwards the outbreak commenced. The Caterham and Redhill epidemic in 1879 was traced to the defilement of a conduit by the stool of a workman who had contracted a mild form of the disease. "The outbreak took place simultaneously in Caterham and Redhill, exactly fourteen days after the water-supply had been befouled in this manner." In 1884 an outbreak occurred at Beverley (Yorks). The drainage from the East Riding County Lunatic Asylum, in which there had been cases of enteric fever, was discharged over a field adjoining the Water Company's works. Certain defects were found in the well, and there was no doubt the imperfectly purified sewage effluent had reached the well. Numberless cases of epidemic outbreaks have been traced to the use of water polluted by sewage not known to have been specifically infected. Several such outbreaks were due to the insuction of filth from closet pans flushed directly from the mains, and many to causes already illustrated. There is no doubt that the majority of the recorded small outbreaks are due to the use of polluted well water, and a careful study of these cases shows that in nearly every instance the pollution was obvious and gross. Where a well is properly constructed the risk of pollution is infinitesimal, and there are no authentic records of water from such a well causing disease. The Maidstone outbreak (1897), one of the most serious which has occurred in this country, was entirely attributable to the pollution of a spring, one of the several sources of supply to the town. This spring arose at the edge of some highly manured hop-fields, and must inevitably from time to time have become polluted. Specific infection could not be traced. In 1889 a serious outbreak of typhoid fever occurred at New Herrington (Durham), 278 out of a population of 3600 being attacked. The water-supply was from a deep well, and the polluting matter, to which the outbreak was attributed, travelled from a farmyard three-quarters of a mile away through fissures in the rock and reached the well at a depth of forty-five feet. The reports of the Massachusetts Board of Health contain many records of epidemics due to the use of polluted river water, and many such epidemics have occurred in this country, notably in the Tees and Trent valleys. London, supplied chiefly from the Thames and the Lea, experiences no special prevalence of typhoid fever, although the rivers receive enormous volumes of imperfectly purified sewage effluents; this is attributable in part to the great dilution, but chiefly to the great care taken in filtering the water before distribution.

To account for the outbreaks of typhoid fever from the use of sewage-polluted water it has been assumed that the bacillus coli communis, found in all fæcal matter, is merely a degenerate non-virulent form of the typhoid bacillus, which may, under certain circumstances, again become virulent. There is no reliable evidence in proof of this assumption.

That cholera is very frequently a water-borne disease is undoubted. That such was the case was suspected in the 1849 epidemic, but in 1854 an outbreak in London furnished conclusive proof. This outbreak occurred round Golden Square, Westminster, and was entirely limited to households using water from what was known as the Broad Street pump. About seventy-eight hours before the general outbreak it was found that a child had suffered from a fatal attack of "diarrhœa," and the stools had been thrown down a drain which ran near the well. This well was so defective that it was easily demonstrated that the sewage entered it. The much more recent outbreak at Hamburg was investigated by Koch, and attributed entirely to the use of the imperfectly purified water from the Elbe. The neighbouring town of Altona remained free from the disease until an accidental breakdown occurred at the water filtration works, which allowed impure water to be supplied for a short time to the town. Immediately afterwards cholera broke out in Altona.

Entozoal disease may be contracted from drinking water containing the ova of such parasites. In this country there is evidence that the ova of Ascarides lumbricoides and Oxyuris may gain access to the system through the medium of water—in my experience generally from the use of polluted pond water. Other entozoa infecting man, and which may be introduced by impure water, are:—Bilharzia hæmatobia, Filaria sanguinis hominis, Dracunculus medinensis, Rhabdonema intestinale, Trichocephalus dispar, and possibly species of tænia.

The effect upon animals of drinking impure water appears to have received very little attention, but outbreaks of anthrax, hog cholera, and glanders have been attributed to this cause. Farmers whose cattle have to drink water from polluted streams often attribute outbreaks of disease thereto, but such outbreaks are rarely carefully investigated. Probably such investigations would show not only that impure waters are inimical to the general health of cattle, but also a danger to those who consume their milk and flesh. A pure water should certainly be insisted upon for all dairy purposes, as notwithstanding the most careful supervision such water may contaminate the milk.

Public water supplies should be of such a character that the water requires no further purification by the consumers. Water derived from carefully protected springs or from deep wells requires no treatment whatever, but surface waters usually require careful filtration. During certain seasons minute forms of vegetable life are apt to occur, and these, either by their growth or decay, may render the water unsightly or even unpalatable. River waters, or water from any source liable to sewage contamination, should be efficiently purified before distribution. By proper collection in large reservoirs sedimentation occurs, and the sunlight destroys many bacteria; finally, filtration through beds of sand will remove over 99 per cent of the remaining organisms. This filtration, to be efficient, must be conducted in a scientific manner. Koch, who has paid great attention to this subject, asserts—(1) That the real effective agent in removing micro-organisms from the water being filtered is the layer of slimy organic matter which forms upon the surface of the sand. (2) That if this surface be removed by scraping, or its continuity affected in any way, as by the freezing of the surface, the number of bacteria which pass through the filtering material increases considerably; in fact, both cholera and typhoid germs may pass in sufficient numbers to cause an epidemic amongst those who use the imperfectly filtered water. (3) That water should not pass through the filters at a rate exceeding two million gallons per acre daily. (4) That after a filter bed has been scraped, water should be allowed to stand upon it for at least twenty-four hours, to allow of the slime depositing before filtration is commenced, and that the water which first passes through should not be allowed to reach the pure water reservoir. He also asserts that filtered water containing more than 100 germs, capable of development, in a cubic centimetre should not be considered as sufficiently pure for distribution.

Many inventors have patented processes for purifying water on a large scale without recourse to sand filtration, as this not only requires the exercise of great care, but necessitates the possession of considerable areas of land for the construction of filters. These machines may be useful under certain circumstances, but of the many which I have examined not one produced results which could be compared with efficient sand filtration.

Domestic supplies may be purified in various ways. Where the impurities to be removed are of mineral origin, fine sand, clay, etc., or vegetable growths occurring in an otherwise unimpeachable source of supply, there are many filters which are efficient. If, on the other hand, there is the slightest suspicion of sewage contamination, the only safe methods of purification are (*a*) boiling, (*b*) filtration through materials which will remove all bacteria. Boiling for a few minutes destroys all disease-producing organisms, and is therefore thoroughly reliable. The only filters which can be relied upon to remove all bacteria are Pasteur's and the Berkfeld candles. These are hollow cylinders of porcelain (Pasteur) or compressed kieselguhr (Berkfeld), and the water in passing through the walls of the filter leaves the organisms and other sedimentary matter, usually slimy in character, on the surface of the filter. The Pasteur is the more reliable, and being harder is more durable than the Berkfeld, but it filters much more slowly, and is practically useless unless the water can be put under pressure. By employing a large number of cylinders, a so-called battery, a slight pressure will suffice. With the Berkfeld the same result can be obtained with little or no pressure, but the pores being more open the action of the filter cannot be relied upon for as great a length of time. Moreover, when the cylinders are removed for cleansing, brushing and boiling in water, or roasting over a red fire, they are more liable to fracture. A number of forms of these filters are made for attaching to taps, pumps, cisterns, etc. All the ordinary forms of domestic filter are practically useless for removing bacteria, they are simply fine strainers, and may produce a bright and sparkling water containing even more bacteria than the original unfiltered water. Equally good results can be obtained from a filter costing but a few pence, and made by filling a flower-pot with layers of fine gravel and sand. Dr. Bond, Medical

Officer of Health for the Gloucestershire Combined Districts, has recently introduced a "floating film" filter, which consists of a cage of fine wire surrounded by a film of porous material, which can be obtained at about one shilling each, and fresh mantles or films at 1d. to 2d. each. The rate of filtration can be controlled. They certainly remove all visible suspended matter better even than many high-priced filters, but they cannot be depended upon to remove bacteria however slow the filtration.

Very hard waters may often be softened economically, and during the process a certain amount of bacterial purification is effected. This hardness depends upon the presence of salts of calcium and magnesium, usually carbonates and sulphates. The carbonates being held in solution by carbonic acid are precipitated by boiling, which drives off the carbonic acid. The hardness so removed is called "temporary." The hardness due to the sulphates not being removable by boiling, is called "permanent." The softening process consists in the addition of lime water, or of soda ash in solution, to the water. The free alkali combines with the carbonic acid, and the calcium carbonate is thrown down ($CaCO_3, CO_2 + CaO = 2CaCO_3$). When soda ash is used the sulphates are also decomposed ($MgSO_4 + Na_2CO_3 = MgCO_3 + Na_2SO_4$), so that both the temporary and permanent hardness are reduced. The carbonates in separating carry down with them many of the suspended bacteria, hence not only is the water softened, but bacterially purified. Water which contains so much of the calcium and magnesium salts as to produce an insoluble curd with soap are called hard, whilst those which form little or no curd and lather freely are called soft. There is no doubt that a soft water is far more economical and better adapted for domestic purposes than a hard water. It economises soap, is better adapted for tea-making and general culinary purposes, does not fur boilers, and minimises labour in washing, but there is no evidence that it is more beneficial to health. The Royal Commission on Water-Supply went fully into the question of the effect of hard and soft water upon health, and concluded that "where the chief sanitary conditions prevail with tolerable uniformity, the rate of mortality is practically uninfluenced by the softness or hardness of the water supplied to the different towns." The opinion that "soft water" increases the tendency to rickets and "hard water" to the production of renal calculi is quite unfounded. The late Sir B. Ward Richardson was strongly of opinion that hard waters produced dyspeptic symptoms in persons unaccustomed to their use, and it is probable that soft water has a tendency to produce diarrhœa in persons accustomed to the use of hard water. Both effects are probably very temporary, and may account for the derangements from which persons visiting health resorts frequently suffer.

There are many makers of water-softening apparatus, some of which are adapted for use in mansions, public institutions, etc. Probably the most generally useful is the one made by the Maignen "Filtre Rapide" Co., which softens and filters the water automatically.

From what has been said, it will be evident that a water which does not contain such an excess of saline matter as to cause it to be too hard, and is free from lead or from an excessive amount of iron or zinc, and which gives no indications of sewage matter, and of more than a trace of vegetable matter, is hygienically pure and fit for domestic purposes. Whether this is so or not can be fairly well determined by bacteriological and chemical examination, but no such examination can be depended upon to indicate danger of pollution. A source which may usually yield a pure water may, if not properly protected, suffer from occasional contamination, and is therefore unsafe. Quite recently I investigated an outbreak of typhoid fever which the Medical Officer of Health attributed to the use of water from a certain spring. A sample of the water was sent to an analyst, who certified that it was pure, and went out of his way to assert that it could not possibly have caused typhoid fever. Upon investigation I found that the spring water had recently been noticed to become turbid after rain (always suggestive of pollution), and the cause was traced to a sewer broken at the crown. During dry weather no sewage escaped, during heavy rains the sewer filled, and sewage matter escaped and polluted the spring. Further, the sewer was traced to an isolation hospital in which there had been a case of typhoid fever, and a sample of the water collected after a heavy rainfall was found upon analysis to be highly polluted. An examination of the *source of supply* is therefore even more important than an analysis, and the nature of the source should always be considered when giving an opinion. Where a source is obviously open to pollution an analysis is unnecessary; where there is no possible source of pollution near the analysis is of little importance, and might almost be confined to the examination for hardness and noxious metals. For sanitary purposes the chemical examination is generally confined to the estimation of the hardness, chlorides, nitrites, nitrates, lead, iron and zinc, and ammoniacal and organic matter. The *bacteriological examination* may include the examination of the number of bacteria per cubic centimetre capable of growing on nutrient jelly, and tests for the presence of the bacillus coli communis and bacillus enteritides sporogenes, organisms always found associated in sewage and manure. The physical properties, colour, odour, and turbidity should also be noted. Such examinations require to be performed in a fairly equipped laboratory, in fact they are best undertaken in laboratories established especially for the purpose. I, however, have devised a small cabinet containing all the requisites for a simple chemical analysis. It is made by Messrs. Burroughs, Wellcome and Co. That the cabinet and process is fairly satisfactory may be inferred from the fact that it has been adopted by Government, and a special case devised for saddle or shoulder. In this method[1] the reagents are in the form of "soloids," which keep well and contain a definite quantity in each. All the above chemical determinations can be made, and with a knowledge of the source from which the water is supplied, in the great majority of cases a correct opinion upon the character of the water can be given. In the ordinary laboratory the examination is made in the following manner:—

Colour and Turbidity.—Fill a 100 c.c. cylinder, place on a white slab and look down the column of liquid. Note the appearance.

Odour.—Put about 100 c.c. into a boiling flask, warm to about 120° F. Insert the rubber stopper, shake vigorously, remove the stopper, and apply immediately to the nostrils.

Residue left on Evaporation.—Evaporate about 20 c.c. to dryness in a platinum or porcelain dish. Note character of residue, then ignite very gently, and note any change which occurs.

Nitrites.—Place about 50 c.c. of the water in a Nessler glass, add 1 c.c. of zinc iodide and starch solution, and 1 c.c. of dilute hydrochloric acid. Allow to stand for five minutes. A blue colour indicates nitrites.

Nitrates.—If nitrites are absent add a minute quantity of zinc dust and stir. A blue colour will develop more or less rapidly according to the amount of nitrates present. If the water contains very little nitrate 50 or 100 c.c. must be taken for the next experiment, if much is present 5 to 20 c.c. will suffice.

In a 250 c.c. tubulated flask, place 20 or 30 grams of granulated zinc, coat with copper in the usual way, wash well, then add 100 c.c. of distilled water and 20 c.c.

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[1] *A Simple Method of Water Analysis*, 3rd edition, 2s. 6d. J. & A. Churchill, London.

of caustic soda solution. Distil, collecting 10 c.c. at a time until the distillate is free from ammonia. Now pour into the flask the measured quantity of water by means of a pipette, distil over 50 c.c. Add to the liquid in the flask 50 c.c. of pure distilled water, and distil a second 50 c.c. Nesslerise the distillates. The amount of ammonia obtained multiplied by ·823 gives the nitric nitrogen in the quantity of water used for the experiment, and must be calculated to parts per 100,000.

Chlorine.—Measure 100 c.c. of water into a white porcelain capsule, add 10 drops of solution of chromate of potassium, and run in standard silver nitrate solution from the burette until a red tint appears. Each c.c. of silver solution used represents one part of chlorine in 100,000 of water.

Total Hardness.—Measure 100 c.c. of water into a 250 c.c. stoppered bottle, and add standard soap solution from a burette, with constant agitation, until an abundant lather is produced. (Similar to that produced by 1 c.c. of the soap solution in 100 c.c. of distilled water.) The number of c.c. of soap solution used minus 1 gives the hardness per 100,000 parts.

Permanent Hardness.—Place 150 c.c. of the water in a boiling flask and boil gently for 15 or 20 minutes, adding a little distilled water from time to time to replace that lost by evaporation. Allow to cool, make up to 150 c.c. and filter off 100 c.c. The hardness in this is estimated as above and represents the permanent hardness.

Temporary Hardness.—The total hardness less the permanent hardness gives the temporary hardness.

Lead and Iron.—Place 50 c.c. of the water in a Nessler cylinder, and add about 5 drops of the solution of calcium polysulphide. A brown tint indicates lead or iron. Add dilute HCl drop by drop until the liquid becomes turbid. If the brown colour disappears the impurity is due to iron, if the brown tint remains lead is present. The amount may be very simply estimated by contrasting the tint produced with that in artificially prepared solutions containing known amounts of lead.

Zinc.—Place 50 c.c. of water in a Nessler cylinder, very faintly acidulate with HCl and add 2 or 3 drops of solution of potassium ferrocyanide. Put in a *dark* place for half an hour. If a turbidity is produced zinc is present. (If iron be present the liquid will become blue, if copper, a red tint develops.)

Free Ammonia.—Place 250 c.c. in a boiling flask and distil over 50 c.c. Unless the water contains a great excess of ammonia the whole is found in this distillate. The amount of ammonia in this distillate is determined by the process of "Nesslerisation." This consists of adding to the distillate 2 c.c. of Nessler's solution (a solution of mercuric iodide in caustic soda or potash), and imitating the depth of colour produced by adding Nessler's solution to pure distilled water to which definite quantities of solution of ammonium chloride have been added. The ammonium chloride solution is made of such a strength that 1 c.c. corresponds to ·01 mg. of ammonia. The water remaining in the retort is used in the next experiment.

Albuminoid Ammonia.—Distil over another 50 c.c. and pour into the distilled water bottle. Add by means of a funnel 25 c.c. of alkaline solution of permanganate of potassium and distil off two 50 c.c. Nesslerise as before.

The amount of ammonia obtained in the two last experiments multiplied by ·4 gives the ammonia in 100,000 parts of water. If multiplied by 4 the result will be in part per million.

Oxygen Absorbed.—Use a solution of permanganate of potassium, each c.c. of which represents ·1 mg. of available oxygen. In a stoppered flask (thoroughly well cleansedwith dilute acid to which a little permanganate has been added and afterwards rinsed) place 250 c.c. of the water to be examined together with 10 c.c. of dilute sulphuric acid (25 per cent), and 10 c.c. of the dilute permanganate. Keep at 80° F. for four hours. If the colour fades much add a second 10 c.c. of permanganate.

Prepare a dilute solution of sodium thiosulphate by diluting 1 c.c. of a strong solution to 100 c.c. with distilled water.

To the water which has stood for four hours add 2 c.c. of solution of starch and zinc iodide, and run in from a burette the dilute thiosulphate solution until the blue colour just disappears. Note the amount a required. Now add 10 c.c. of the dilute permanganate solution, and again titrate with the thiosulphate. The amount b now used is the equivalent of 1 milligram of oxygen. Then

$$\frac{b-a}{b} = \text{oxygen consumed by 250 c.c. of water.}$$

This multiplied by ·4 gives the oxygen absorbed in parts per 100·000; if multiplied by 4 the result is in parts per million.

Bacteriological Examination of Water.—1. *Number of Colonies per Cubic Centimetre.*—Make two gelatine plates (Petrie dishes) using ·5 and 1 c.c. respectively of the water to be examined. Incubate at 20° C. for four days. Examine the plates daily, and if liquefaction is setting in count the number of liquefying and non-liquefying colonies. Non-liquefying colonies resembling those of B. typhosus or B. coli may be counted and picked out for further experiments.

Jelly of uniform composition and reaction should always be used. All the colonies visible under a small hand lense should be counted.

2. *Examination for Bacillus Coli.*—Add 1 c.c. of the water to 10 c.c. of broth containing ·05 per cent of phenol. Incubate at 36° to 37° C. for 24 hours. Should a uniform turbidity be produced examine in the hanging drop, and if the organism is a motile bacillus: (*a*) stain the flagella by van Ermengen's method; (*b*) make a shake gelatine culture for formation of gas bubbles; (*c*) inoculate a broth tube for indol reaction; (*c*) inoculate litmus milk for production of acid and coagulation of casein.

3. *Examination for the Spores of Bacillus Enteritidis Sporogenes.*—Pass 250 or 500 c.c. of the water through a very small Pasteur filter, and brush the residue into 10 c.c. of sterile milk. Place the tube in a water bath, and keep at 80° C. for 15 minutes. Pour about 2 grams of melted vaseline over the surface of the milk and cool. The vaseline effectually excludes the air and if the milk be now placed in an incubator for 24 to 48 hours, any spores of the bacillus present will germinate, and the presence of the organism be revealed by the coagulation of the casein in torn irregular masses, having the faintest possible pink tint and the evolution of gas which forces up the vaseline plug. Upon removal of this plug the gas will be found to be inflammable and the liquid has a strong odour of butyric acid.

Interpretation of Analytical Results.—A filtered water which contains more than 100 organisms per cubic centimetre capable of growing on nutrient jelly is not efficiently purified, but it must be remembered that this enumeration is of little value unless the water is examined immediately after it leaves the filter beds. The harmless bacteria found in water multiply rapidly, hence a water may contain 1000 or more organisms per c.c. and yet be perfectly wholesome. If, however, both the B. coli communis and the B. enteritidis sporogenes are found to be present there can be no doubt that the water is polluted and unfit for domestic purposes.

A water with a greenish or yellowish tint is generally contaminated, but it may be merely with a trace of vegetable matter. A brownish tint usually indicates "peat," and this, unless very excessive in amount, is quite harmless. A pure water should be practically colourless and free from any appearance of turbidity when viewed in a column six inches in depth. A peaty water may have a faint odour, but an odour from any other cause renders the water suspicious.

All waters contain chlorides, hence the chlorine determination has no great value. No inference can be drawn as to sewage contamination from the amount of chlorides present unless the analyst knows how much is contained in water of known purity from the same source. Sewage contains chloride of sodium (found in the urine), but considerable pollution must take place before it is recognisable by its effect upon the chlorides. Near the sea or tidal rivers the subsoil may be infiltrated with salt, and waters therefrom be rendered brackish. If the salt, however, is not in such quantity as to be appreciable to the taste it is harmless.

Sewage undergoing decomposition usually contains nitrites, whereas pure waters, save under very exceptional circumstances, are free therefrom; hence the presence of nitrites always indicates the necessity for careful inquiry as to their source. Nitrates, on the other hand, are the final products of the decomposition of sewage or manure by the micro-organisms in the soil, and indicate the nature of the ground from which the water is collected. Some analysts ignore the presence or absence of nitrates, others lay great stress on the amount present. Nitrates are perfectly harmless in themselves, but they indicate that the subsoil is more or less highly manured, and therefore that pollution may occur unless the well or spring is sufficiently far from the polluting matter, and the soil is sufficiently compact and "live" to be depended upon to effect complete oxidation and filtration. When the water contains an abundance of nitrates and decided traces of organic matter it should be unhesitatingly condemned. The nitrates are usually expressed in terms of nitric nitrogen, 1 part of which corresponds to 4½ parts of nitric acid, or about 6 parts of such nitrates as usually exist in drinking waters. No possible standard can be fixed, but even in agricultural districts, where the subsoil is porous and the soil highly manured, the presence of much over 1 grain of nitric nitrogen per gallon should render the water suspicious.

The hardness of water is usually expressed in degrees, each degree corresponding to the soap-destroying power of one grain of calcium carbonate in one gallon of water. When the soap-destroying power is under 10° the water may be considered soft, or moderately soft; from 10° to 15° it is moderately hard; 15° to 20°, hard; and over 20°, very hard or excessively hard. An excessively hard water is not suitable for most domestic purposes. A water from which much of the hardness can be removed by boiling is preferable to a permanently hard water.

The organic matter in a water cannot be accurately determined, and such a determination is rarely attempted. Other estimations are made which serve as indices of the amount of organic matter present, and at the same time give some indications of its character. Sewage and manurial matters yield much free ammonia on distillation, and after this has been distilled off a further quantity of ammonia can be obtained by the action of a strongly alkaline solution of potassium permanganate on the albuminous matters. This is called "organic" or "albuminoid" ammonia. Further, these impurities absorb considerable amounts of oxygen from acid solution of potassium permanganate solution, called "oxygen absorbed." Hence the amounts of "free" and "albuminoid" ammonia and of "oxygen absorbed" are considered together in forming an opinion as to the purity of a water. Vegetable matter usually yields very little free ammonia, but may yield as much "organic" ammonia as animal matter; it, however, absorbs oxygen less freely.

Nearly all waters contain a trace of free ammonia, especially rain water, and occasionally a water which has stood for some time in contact with a metal will yield ammonia due to the reduction of nitrates by the metal—zinc, iron, or lead. In such cases traces of the metal can be detected in the water. In waters other than rain waters, or waters containing traces of the above-mentioned metals, the presence of more than ·05 parts of ammonia in one million parts of water should give rise to suspicion. If the "organic" ammonia exceeds ·05 parts per million, and yet is less than the free ammonia, pollution with sewage or manurial matter is indicated. If the "organic" ammonia is under ·10 per million, and the "free" ammonia under ·05, the organic matter is probably of vegetable origin.

The following table by Messrs. Tidy and Frankland was devised for interpreting the results obtained in the estimation of the oxygen absorbed:—

	Amount of oxygen absorbed by one million parts of water.	
	Upland surface water.	Water from other sources.
Water of great organic purity . .	Not more than 1·0	Not more than 0·5
„ medium purity . . .	„ „ 3·0	„ „ 1·5
„ doubtful purity . . .	„ „ 4·0	„ „ 2·0
Impure water	More than 4·0	„ „ 2·0

In interpreting chemical results it must be remembered that the most delicate analysis will not reveal the presence of minute quantities of sewage, hence even waters of great organic purity may actually be contaminated, and a careful bacteriological examination may reveal the presence of organisms derived from sewage or manure.

In taking samples of water for examination great care should be exercised, as the introduction of a very little organic matter from the vegetation around, from dirty vessels, or from a cork, may mislead the analyst. A white glass-stoppered bottle holding about four pints is best. It should be thoroughly cleaned with oil of vitriol, and rinsed out repeatedly with good water. The bottle should then be completely filled with the water to be examined, a little poured away, and the stopper inserted. If the water is collected from a tap, the tap should be turned full on and the water allowed to run to waste for a few minutes before filling. If the sample has to be taken from a cistern, pond, or stream, then, if possible, the stopper should be inserted and the bottle placed well under the surface of the water, and in a few seconds the stopper removed and the bottle allowed to fill. The stopper is best secured by a covering of clean linen, or by an india-rubber cap. Whoever interprets the results of the analysis should be fully acquainted with the source of the water, as the interpretation is not a mere chemical problem.

Under the Public Health Acts it is the duty of all sanitary authorities to see that every house in their districts has an available supply of wholesome water, within a reasonable distance, sufficient for all domestic requirements. But this supply can only be enforced where it can be obtained at a reasonable cost, and this cost is defined as £8:13:4 per house (or by special permission of the Local Government Board, £13). Unfortunately in the great majority of cases a proper well cannot be constructed for this sum, hence many localities continue to be badly supplied with water. The terms "reasonable distance" and "available supply" are variously interpreted in different districts, hence there is great lack of uniformity in the administration of the Acts so far as they apply to water supplies. There are even differences of opinion as to what constitutes a "wholesome water." Where there are considerable congregations of houses it becomes the duty of the sanitary authority to provide a public supply. Unfortunately, again, this duty is too frequently shirked on account of the expense. Where any source of water-supply is so contaminated as to be injurious to health the sanitary authority may cause the source to be closed. This section of the Public Health Act is, however, of little use, since it is difficult to prove that a water is actually injurious to health. If the word "dangerous" were substituted for "injurious" the section would be of much greater value. The law generally relating to water supplies requires amending.

Whitlow. *See* Fingers.

Whooping-Cough.

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Historical Note.—Whooping-cough has been a prevalent disease through many centuries. Von Rosenstein, who wrote in 1771, states that it began in France in 1414, having been imported from Africa or the East Indies.

In the year 1580 it is reported that over 9000 children died in Rome from this disease alone. The earliest distinctive accounts of it were by Baillou in 1600 and Schenck in 1650. Prior to this period it does not appear to have been distinctly differentiated from such diseases as bronchitis or influenza. In the eighteenth century it is reported to have been generally epidemic over Europe, and we find the literature of the subject embraces the writings of many distinguished physicians at this time, more especially in England, Sweden, and Germany. Among the more important monographs were those of Hoffman, von Rosenstein, Stoll, Butler, Willis, and Biermer, the latter having written an account of all the epidemics during the century. It had all along been recognised as a contagious disease, and the general consensus of opinion tended to show that it was due to disorder of the digestive system, reflecting an irritation on the respiratory organs. During the nineteenth century the literature of the disease accumulated largely, especially in England, France, and Germany, and we find interesting treatises by such men as Trousseau, Barthez and Rilliet, Copland, Webster, Jahn, Kruckenberg, and many others. A mere epitome of the views of these and other well-known physician during the last four centuries would occupy an extended space. Even at this time the older and more antiquated views of the nature and origin of the disease held their ground, with other additions to the many theories then prevalent. While the contagious nature of the complaint was fully recognised, no definite pathological facts had been adduced to form any foundation for the mass of theoretical reasoning. The theory which found most favour, especially among English physicians, was the neurotic one, whereas many of the German writers held to the view that it was the result of primary affection of the bronchial lymph nodes producing pressure on the branches of the vagus, and thereby exciting reflex irritation. The French school held strongly to the theory that it was essentially a catarrhal affection of the respiratory tubes, complicated in severe cases by irritation of the central nervous system. Oppolzer considered the irritative cough was excited by foul secretions in the pulmonary alveoli. Letzerich was one of the first who made a step in advance of this, and advocated the view that the morbid catarrhal secretions contained inhaled spores which favoured decomposition and caused increased irritation. Finally, by a more or less general consensus of opinion the disease was classed among the zymotic group, and believed to be caused by a definite infection which localised itself in the first place in the air passages. It is interesting to note how through the theoretical groping of centuries the true cause of the disease was gradually approached, and is now being worked out on the lines of bacteriological investigation as applicable to the whole group of these diseases.

Definition.—It may be defined as a contagious and infectious disease, the leading symptom of which is a spasmodic or convulsive cough, associated with a catarrhal condition of the mucous membrane of the respiratory tract, principally of the nasal, faucial, laryngeal, and tracheal surfaces, as well as the larger bronchi, but which may also extend to the smaller bronchial ramifications. The cough is essentially paroxysmal in character, and recurs at intervals more or less frequent, the patient being free from cough at other times. The cough when fully developed is highly characteristic, and consists of a rapid succession of expiratory efforts accompanied by spasm and narrowing, or it may be closure of the glottis, which is followed by relaxation of the spasm, the inspired air rushing in with a whooping sound. The cough is ended by expectoration of tenacious mucus, often accompanied by vomiting. The whooping sound is loud and distinct in proportion to the severity of the spasmodic effort, not so marked or sometimes absent when the cough is less severe and forcible. There is a liability to various complications to be afterwards referred to. No more concise or true definition of the disease has been given than by Cullen, who summarises in a few words its leading characteristics, "Morbus contagiosus, tussis convulsiva, strangulans, cum inspiratione sonora, iterata, sæpe vomitus."

Whooping-cough is essentially an epidemic disease, rarely occurring sporadically. No conditions, telluric, atmospheric, or seasonal, are known in any way to influence its spread, nor do we know whether the contagium has any habitat outside the body. It occurs over all quarters of the globe quite independent of climate, which seems to have no influence either in its spread or in regulating its inception.

Season seems to have little or no influence in initiating or diffusing the disease, although in winter the epidemics are almost invariably attended by a larger mortality. This may probably be accounted for by the fact that hygienic conditions are less favourable at this season, the patients being unable to get out to the open air as frequently as in spring and summer. *Sex* as a predisposing cause seems to have a certain influence, girls being more susceptible than boys. *Age* has a powerful effect in causation. It is essentially a disease of childhood, although adults are not exempt. Strange to say sucking infants seem to be less liable to it than older children. Statistics show that the period of greatest susceptibility is from two to five years. Cases have been met with where the fœtus has contracted the disease from the mother in utero, the infants showing all the characteristic symptoms a few hours after birth. In the case of adults as of children, women are more liable to infection than men, pregnant women more particularly so. The relation of this disease to other epidemics is interesting. It is well known and universally recognised that whooping-cough epidemics frequently precede or succeed outbreaks of the exanthemata, specially of measles and chicken-pox. The disease may also coexist with any of these diseases, particularly measles. In such cases the complication is often of great gravity, and predisposes to a fatal result.

Mortality.—Whooping-cough is one of the most fatal diseases of early life, particularly during the period of infancy and until the third year. After this the mortality gradually diminishes with advancing age. The mortality tables in England over a series of years show an average of 2 per cent from this disease, and the Registrar-general brings out a similar average for the last ten years in the eight principal towns of Scotland. The mortality in females always exceeds that in males. Previously healthy children of naturally sound constitution show a much smaller mortality than those of delicate constitution, or such as have been debilitated by previous disease. The fatality in the simple uncomplicated disease is small, complications generally being the cause of death.

MORBID ANATOMY AND PATHOLOGY.—Uncomplicated whooping-cough is rarely a fatal disease. In those cases which have been attended with a fatal result little has been found except a catarrhal condition, more or less marked, of the upper air passages, particularly of the larynx, on the laryngeal surface of the epiglottis, and on the intra-arytenoid mucous membrane. The bronchial glands are usually in a hyperplastic condition, and there may be passive congestion of some of the internal organs, more especially the brain. The lungs show patches of emphysema here and there.

The disease being of a zymotic nature caused by a specific materies morbi, no efforts have been spared by pathologists in recent years to detect the organism or organisms which cause the disease. It cannot be said that the question is definitely settled, although various organisms have been found in the catarrhal secretions of the respiratory surfaces. Letzerich, Poulet, Burger, and Deuchlar have all found different micro-organisms, but failed to identify any with the disease. Following these observers Afanassieff made numerous experiments on rabbits, which he inoculated with pure cultures of a bacillus which he found in the secretion, with the result that symptoms resembling pertussis followed. He found the same organism in children who had died of pertussis pneumonia, and believes this organism is the cause of the disease. Semtcheno repeated and confirmed Afanassieff's experiments. Koplik, one of the most recent investigators, considers he has discovered the specific organism, an anaerobic and motile bacillus with rounded ends. The organism closely resembles that discovered by Afanassieff. Inoculation experiments in animals gave negative results in Koplik's investigations. Capelewski, however, who found the same organism, was attacked by severe catarrhal symptoms while conducting his experiments. More recently Behla has described an organism which he says is not a bacterium, but a protozoon, an amœba. Deichler and Kurloff have also expressed a like opinion. The organism increases by division and also by spores. The chief site of the parasite is in the larynx and trachea. It is interesting, further, to note that several of these observers discovered a toxin in the urine of children suffering from pertussis, and this was found to be identical with that obtained from pure cultures of Afanassieff's bacillus. As already stated, most of the fatal cases die from some complication which has involved one or more organs, and a reference to these may now be made.

Brain.—In addition to passive congestion of the cerebral vessels in rare cases meningeal hæmorrhages have been found, and sometimes effusion into the ventricles. The cerebral substance itself is never found to present any morbid appearances.

Abdominal Organs.—Apart from more or less congestion of the blood-vessels no changes have been found. Owing to the fact that the urine is frequently found to be saccharine the kidneys have been carefully examined by many pathologists, but without any evidence of gross lesion.

Heart.—During the paroxysmal fits of coughing the circulation is very much disturbed and the aeration of the blood temporarily interfered with, yet no heart lesion has been found either of the endocardium or muscular substance.

Conjunctivæ and Respiratory Mucous Surfaces.—The conjunctivæ are almost invariably found to be congested, and not infrequently hæmorrhage occurs from the vessels. The mucous surfaces of the nose, larynx, and bronchi are congested and somewhat swollen with excessive mucous secretion on the surface. *Emphysema*, as already noted, is rarely absent from the lungs. *Pulmonary collapse* is likewise of common occurrence, the excessive force of the expiratory effort emptying the alveoli of the contained air.

Catarrhal pneumonia is a frequent and serious complication, and the morbid appearances are indistinguishable from those found in this disease produced by other causes.

Tracheo-bronchial Adenopathy.—The constancy with which these glands are enlarged have led physicians of repute to promulgate the theory that this was the primary and essential cause of the disease, but the fact that the glands are enlarged from many other causes in cases where there is no spasmodic cough effectually disproves the allegation. One other morbid appearance deserves notice, and is met with in children after the dentitional period. I refer to ulceration of the frænum linguæ produced mechanically by the forcing of the tongue forwards on the lower incisor teeth.

Symptoms.—From the consideration given to the nature of the disease we conclude that it must be classed among the zymotic group, and that it is caused by a specific materies morbi, which, although not yet definitely determined, is of the nature of a micro-organism which attacks the respiratory mucous surface on which it grows, and produces a toxin which gives rise to more or less constitutional disturbance. This toxin does not cause much febrile movement, as do the toxins of the other zymotic diseases, for we rarely find the temperature above 100° or 101°, and that only during the first few weeks of the disease. The most marked effects of the toxin would seem to be determined in the central nervous system, and more especially that portion of it closely related to the respiratory apparatus in the lower motor neuron in the region of the nuclei of the vagus nerve. The upper motor neuron in the cerebral cortex would appear to be often gravely affected by the toxin of pertussis from the frequency with which convulsions occur in this disease. As in other zymotic diseases, the symptoms naturally arrange themselves with more or less regularity in certain stages.

The *incubation* period is not exactly known. It is probably variable, perhaps more so than in other diseases of the zymotic group, ranging from two or three days to as long as fourteen. During this time the patient is apparently in average health.

The ordinary symptoms of the disease commence with the *catarrhal stage*, in which the child appears to suffer from a "cold," with slight cough, often of a short, hacking character, catarrhal discharge from the nostrils and sneezing, and congestion of the conjunctivæ with "watering of the eyes." If the temperature be taken at this stage it is found to be slightly elevated, perhaps not over 100°, for a few hours during the day. There is more or less anorexia, with slightly furred tongue, and a tendency to, or perhaps the actual occurrence of, nausea and vomiting. The child is generally irritable and fretful, and the sleep disturbed. The duration of this stage varies. In severe cases it is generally short, perhaps only two or three days; in moderately severe cases it may continue from one to two weeks, or even longer; and in some cases, and these are frequent in mild epidemics, the disease never passes on to the second or convulsive stage, and convalescence may be established in from a fortnight to three weeks. It is important to remember this in relation not only to diagnosis, but prophylaxis, as these cases spread the disease as readily as the more severe or fully developed cases, and should be isolated accordingly.

The *spasmodic* or *convulsive stage* is evidenced by the full development of the characteristic cough. During the catarrhal stage the cough is of a short and irritable character, occurring at irregular intervals, but cannot be said to possess any specially distinctive symptoms on which a positive diagnosis could be based. In this stage the cough is highly characteristic, and its true nature is readily apparent even to a casual observer. It occurs at intervals of tolerable regularity, and is always more frequent at night. The number of paroxysms vary infinitely according to the severity of the disease, from twelve or twenty to thirty or forty, or even more, in the twenty-four hours. The child is aware of its onset for a short time previously, and displays a certain restlessness and irritability. When the cough begins the child, if old enough, prepares to support itself by laying hold of anything that may be at hand, such as a chair or other article of furniture. The cough commences by a rapid succession of expiratory efforts, succeeded by a long inspiration, during which the whooping sound is produced by the sudden rush of inspired air through the partially relaxed glottis. This is followed by the expectoration of viscid tenacious mucus, or by vomiting, during which the stomach is emptied of its contents. During the cough the child's face becomes much congested, often livid, giving the appearance of impending suffocation. There may be bleeding from the mouth, nose, ears, or any of the mucous surfaces. After the fit the child is more or less exhausted, but often resumes its playfulness in a very short time. The action of the heart during the fit is much accelerated, and the pulse rapid. Auscultation of the lungs shows generally coarse, moist sounds in the larger bronchi, which usually disappear after the fit. The child's face during this stage of the disease is usually characteristic, presenting often a more or less congested appearance, especially of the conjunctivæ, with puffiness of the eyelids. In young infants the convulsive paroxysm of this stage of the disease presents a somewhat different picture; the convulsive efforts may be described as more of a tonic nature, in contradistinction to the clonic and interrupted spasm of the older child, the glottis seems to close rapidly, and the whole muscular respiratory apparatus, intrinsic and extrinsic, seems to be in a state of tonic contraction, during which the infant is veritably in a state of suffocation. On relaxation of the spasm there is seldom any whooping sound produced.

COMPLICATIONS AND SEQUELÆ.—These are numerous and important, as it is the complicated disease that causes fatality.

Respiratory System.—*Emphysema* and *pulmonary collapse* go hand in hand, and are the direct result of the spasmodic effort during the second stage. In a few rare cases we meet with interstitial pulmonary emphysema, which can only be recognised during life when the air gets into the peribronchial tissues and passes to the anterior mediastinum, showing itself in the jugular fossa and at the root of the neck as subcutaneous emphysema.

Bronchitis of the larger tubes is present in most cases, and if the medium and smaller branches of the air tubes are unaffected it is of little moment. When the capillary bronchi and the alveoli are attacked we are face to face with one of the most fatal complications, pertussis pneumonia, caused by the pertussis bacillus and other organisms.

Circulatory System.—In severe cases the strain on the heart is great, and yet it is seldom the organ suffers in a serious degree. Not unfrequently dilatation of the right ventricle results, and the child suffers for a time from pulmonary regurgitation and other symptoms of inadequacy of the right heart. Dr. Cima, in investigating the condition of the blood in pertussis, finds leucocytosis present in all well-marked cases.

Hæmorrhages are frequent in almost any part of the body. Thus we have epistasis, subconjunctival hæmorrhage, slight streaky hæmorrhages from the fauces tinging the expectorated mucus, hæmorrhages from the ears, a rare occurrence, cerebral hæmorrhages, almost invariably meningeal, producing different varieties of cerebral symptoms, convulsions, hemiplegia, monoplegia, or other forms of localised paralysis, or affection of the special senses. As a rule convulsions or paralytic symptoms after pertussis pass off in a few weeks, the probability being that the hæmorrhage has been capillary and small in amount. Fatal cases have been recorded, proving the occurrence of hæmorrhages.

Digestive System.—Ulcer of frænum linguæ, hernia, prolapsus ani, gastric and intestinal catarrh. In cases where the child does not vomit freely, but swallows quantities of the mucus loaded with micro-organisms, an irritative catarrh is set up in the gastro-intestinal mucous tract, which often proves a serious complication.

Nervous System.—The effects produced in the brain by minute meningeal hæmorrhages has already been referred to, and also the less serious general effects of the toxin on the brain. These, of course, vary indefinitely according to constitutional tendencies of the child, delicate and hereditarily neurotic children suffering most severely.

Horvem, in an elaborate monograph on the subject of the paralyses of pertussis, treats more particularly of the rarer forms, and finds that in addition to the cerebral conditions which are most commonly found, cases of bulbar origin are met with. He notes also the occurrence of paraplegia, and cases resembling Friedreich's ataxia and disseminated sclerosis and peripheral neuritis (polyneuritis).

Apart from brain and lung lesions, pertussis in its immediate effects rarely leaves behind it any gross lesions of other organs. Perhaps the most important, because the most common, of the remote effects of this disease are manifested in general ill health and debility which often for many months affect the child, and this predisposes to one of the most serious and remote sequela of this disease, tuberculosis. In the records of my hospital cases of tuberculosis this is plainly brought out. No other disease, I believe, except measles, has such a powerful influence in preparing a soil for the ready reception of the tubercle bacillus.

Urinary System.—Transient albuminuria, probably due to congestive conditions, is not infrequent, and Gibb has pointed out the occasional occurrence of glycosuria.

Treatment.—In these days of enlightened sanitary science much is being done to check the spread of and stamp out zymotic disease. In regard to pertussis, a disease which, roughly speaking, causes about a fourth of the mortality in children in the larger towns of Great Britain, practically nothing has been done. It has not yet been included in the list of notifiable diseases.

Only in schools and public institutions has any attempt been made to isolate or stamp out this disease. Children are allowed to go about in public places, omnibuses, and tramcars, and railway carriages, coughing and vomiting on the public streets and thereby spreading the disease. Isolation is the only means at our disposal to limit the spread and stamp out the disease. Compulsory notification is a necessary first step in arousing the public to a realisation of the dangerous character of the disease in early life. So long as the old ideas prevail, which they do to a large extent, that children are just as well to "get over" such diseases as whooping-cough and measles, so long will this mortality continue. It is only by educating the public that we can hope to carry out a successful prophylaxis. As matters at present exist, what can be done? Among the poorer classes the difficulties are well-nigh insuperable. There is no possibility of isolation in their own homes, and sufficient hospital accommodation is not available. Sanitary authorities should use all possible means to prevent children of one family associating with those of others in contiguous houses, so that the disease may be restricted in its spread to the family originally affected. It ought to be rendered penal to take children suffering from the disease to public places and into public conveyances. The sanitary inspectors should see that the children in the affected house are under medical treatment, and that proper attention is directed to ventilation of the room and other hygienic measures. With regard to children of the better classes prophylaxis is more hopeful. Isolation in the house, if large enough, should at once be attended to, and the other children either removed altogether or kept strictly separate. In my own experience isolation can be successfully carried out in this way. The infection of pertussis requires more or less close contact, and its spread may be as successfully checked in this way as in scarlatina cases. Before removing unaffected children from the house, it is desirable that they should be quarantined in the house for a fortnight, after which time removal may be effected with less risk than in the case of immediate removal. Disinfection of the house and all articles of clothing worn by the child should be attended to, all carpets being taken up, and the floors mopped over with carbolic acid wash. In public institutions, with sick-room and hospital accommodation, isolation may be successfully carried out, the affected children being taken out daily if well enough, at a time when the other children are indoors.

Curative Treatment.—In the treatment of pertussis it is necessary to bear in mind the nature of the disease, a zymotic affection of self-limited duration, with which we have to deal. Our efforts must be directed on general principles to guide the patient as safely through the various stages of the complaint as possible, and to ward off complications. No hard and fast rule can be laid down as applicable in all cases. Mild cases running a favourable course in from two to four weeks require little or no special treatment. In many of these, as has been already indicated, the second stage is hardly reached, or, at all events, the spasmodic efforts are so feeble as scarcely to merit special notice. In cases of average severity and in serious cases a great deal can be done by rational and prompt treatment to mitigate the severity and limit the duration of the disease, the acumen of the experienced physician having ample scope in regulating the treatment according to the special needs of the patient under observation, and avoiding irrational and unscientific routine.

Hygienic.—Pure fresh air is the most important means at our disposal. In suitable weather the patient should be out as much as possible if the case is uncomplicated, and the temperature non-pyrexial. If there is some febrile movement, as there is in most cases for a brief period, the child should be kept in bed. The nursery should be large and airy, the window kept always open. The bed should be placed so as to avoid a cross draught. The clothing should be warm and comfortable, particular care being taken in cold weather to keep the body and limbs from chill. It seems to me that this is one of the diseases of childhood which, in the future, will be treated with advantage on the open-air principle as in tuberculosis. In children there are many difficulties not obtaining in adults in carrying out this method, but I believe it has a great future before it in pediatric practice. In tuberculosis it is now being carried out in children of all ages with even more satisfactory results than in adults. We may reasonably expect that in zymotic and other acute microbic diseases great results may be looked for from open-air treatment.

Dietetic.—The diet during the height of the disease should be lighter than in health and easily digestible, and suited to the age of the child, milk and farinacea with soups forming the staple articles. During the course of the disease in many cases there is a liability to a more or less irritative gastro-intestinal catarrh, due partly to general systemic infection, but also directly to the irritant effects of the secretions from the air passages being swallowed. This is often more marked in cases where the child does not vomit freely several times in the day. In cases in which the vomiting is persistent after every severe paroxysm the child becomes greatly weakened and emaciated from inanition. In these cases it is the rule to feed the child with light and easily digested nutriment shortly after the paroxysm. The quantity should not be too large, but regulated according to the length of interval between the fits.

Medicinal.—The drug treatment of the disease is now conducted on a more rational and scientific basis than formerly. There are few diseases in which so many drugs have been tried, a tolerably sure indication of their general inefficacy.

During the catarrhal stage, whether the patient is confined to bed or not, it is well to give a saline expectorant mixture with liq. ammon. acetat., vin. ipecac., sodæ sulpho-carbolate in water. Benozate of soda may also be used, and is an excellent remedy in this stage. When the convulsive stage is reached drugs of a sedative nature should be given, such as lobelia, belladonna, and in some cases, with caution, morphia. Bromoform is a remedy which has been lauded by many, but in my own experience it is disappointing in its effects. Antipyrin is probably the most efficacious sedative of all. Phenacetin acts in a similar manner, but not with such good effect as antipyrin. Chloral and butyl chloral may be used with advantage in many cases where other sedatives fail. During the stage of decline we should trust to tonic drugs, and the old-fashioned astringent alum, which has well stood the test of time, is often useful. Undoubtedly the only satisfactory tonic in this stage is quinine or cinchona. The liquid extract of the latter may be given with syrup of Virginian prune. Excellent preparations of quinine are the tannate or hydrobromate. During convalescence no remedy does so much good as cod-liver oil, or if there is anæmia, iron. The cod-liver oil should be continued for many months.

Local medication may be applied in solution, vapour, or the insufflation of powders. Careful and persistent local applications to the upper air passages are probably the most effectual means of relief to the irritative effects of poison on the mucous surface, if indeed by such means the disease may not be cut short. Nasal treatment is often of great service, and has in my opinion been too much neglected. Boracic acid is generally used for this purpose, the nostrils being washed out with equal parts of warm water and a saturated solution of the acid two or three times daily, either with an ordinary anterior nasal spray or syphon douche. Spray with 1 to 4000 sol. of hydrarg. perchlor. may be occasionally used in place of the boracic solution, but discontinued if any irritant effects are produced from swallowing small quantities of the solution. Watery solutions of sulphate or hydrobromate of quinine are often of much service when applied in this way to nose and throat. A very useful spray for nostrils and throat is 1 per cent carbolic acid and 3 per cent menthol in paroleine. When the child permits of its frequent and free application it affords great relief.

Insufflations are undoubtedly of much service in many cases where it is possible to apply them, but in my experience this application is difficult in most children. For this purpose quinine is the most efficacious, either alone or combined with one-fourth of resorcin. Iodoform, 1 to 4 of talc, has often a most sedative effect when insufflated into the nostrils. Boracic acid with powdered tragacanth is also a useful powder. *Inhalants* are undoubtedly of great service, and should be commenced during the catarrhal stage, and continued regularly at intervals during the spasmodic period. Carbolic acid, No. 4 or 5 of Calvert's, creseline, naphthalin, and lysol are the best. They should be used in a vaporiser with a night-light, and placed on a table at the head of the child's cot at night, and repeated with more or less frequency according to the severity of the case. I generally recommend two or three inhalations of two hours' duration in twenty-four hours in severe cases. I have not found any poisonous effects as a result. In a well-ventilated room there is generally sufficient dilution to prevent this. Under persistent antiseptic inhalations the cough diminishes in frequency and severity. The only other inhalant which is of service in extreme cases when the paroxysm is so bad as to threaten suffocation is the inhalation of chloroform, a few drops on a handkerchief with or without a drop or two of amyl nitrite.

Intubation.—This has been lately tried and with good effect in very severe cases when the paroxysms are so frequent and the glottic spasm so severe as to exhaust the child in an alarming manner. O'Dwyer's rubber tube must be used instead of the ordinary metal instrument.

The treatment of complications must be conducted on general principles applicable to the various conditions, and does not come within the scope of our present remarks.

Wounds.

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DEFINITION.—A wound is a breach in the skin or a mucous membrane suddenly made by mechanical force, and thus opening a way into deeper tissues. This strictly surgical definition must be distinguished from the medico-legal use of the word, which, by judicial decisions, though not by statute, is held to include such injuries as dislocation and fracture occurring beneath the unbroken skin as a result of violence. The popular application of the term to any open sore is here excluded. Fissures and other solutions of continuity in bone and cartilage, whilst having much in common with wounds, are, in precise surgical language, fractures.

VARIETIES.—It is usual and of practical convenience to classify wounds, according to the appearance of their edges, as follows:—

1. *Incised.*—The injury having been inflicted by a sharp object, as a knife or glass, shows clean-cut edges.

2. *Lacerated.*—In these the margins are irregular and ragged, the parts having been subjected to a stretching or dragging force. Striking examples occur in machinery accidents, as, for instance, where the hair gets entangled in a moving band, and the scalp is torn open and more or less detached by the excessive tension.

3. *Contused.*—Here, also, there is unevenness of the edges; but there is in addition a certain amount of adjacent and subjacent bruising,—that is infiltration of the tissues with blood effused from ruptured vessels,—the extent of bruising varying with the force of the blow and the area and vascularity of the part struck. Wounds of this kind are caused indifferently by the sudden impact of a blunt object, or by a fall against a fixed surface or projection,—the efficient factor in either case being violent pressure or squeezing.

Irrespective of the character of its borders a wound is termed—

(*a*) *penetrating*, when it opens into a joint or cavity of the body;

(*b*) *perforating*, when the lesion extends through a part, so as to produce a wound of exit as well as one of entrance;

(*c*) *punctured,* when the depth exceeds the length; and

(*d*) *infected,* when pathogenic bacteria or their products have entered and set up morbid processes: (*poisoned* wounds resulting from pricks or scratches in making a post-mortem examination are examples of infection, and, in this connection, the special term is unnecessary; though it may be retained for wounds into which chemical, as distinguished from microbic, poisons are instilled).

Bites inflicted by the teeth and beaks of animals combine the characters of bruising and tearing; they are very liable to be infected by material conveyed from the animal's mouth at the time of wounding, though the liability is diminished if the teeth pass through layers of clothing before reaching the skin. The bites of venomous snakes owe their special danger to the poisonous gland-secretion discharged into the wound through grooved or canalised fangs, and giving rise to general toxæmia.

REPAIR OF WOUNDS.—It may be premised that wounds of every kind are repaired by a method common to them all, the final result being that the breach is filled up with organised new material. In some specialised structures as nerve, striated muscle, and tendon, there may be, to a slight extent, an actual regeneration of similar tissue; but as a rule the new formation is a simple connective material known as scar-tissue. Injuries of bone are not here considered, but it may be noted in passing that, whilst their repair is effected by a solid substance, the earlier stages of the process are identical with what is observed in the soft parts.

When the surface-opening of a wound is closed without undue delay, and no disturbance or complication such as septic infection ensues, healing takes place by (1) *primary union,* or by (2) *the intermediation of blood-clot,* or (3) *under a scab.* In the case of an open wound, or the open part of one partially closed, healing proceeds by (4) *granulation,* or, in a later stage, by (5) *the union of granulations.*

1. *Healing by Primary Union or First Intention* is exemplified in the repair of an uncomplicated incised wound, in which the cut edges and surfaces are kept in close contact after all bleeding has ceased. The immediate effect of the injury upon the contiguous zone of tissue is the setting-up of the nutritional disturbances characteristic of commencing inflammation, which proceed to their completion in organisation and resolution in such a manner that the chink of the wound becomes filled with vascularised fibres organically continuous with the neighbouring connective tissue, whilst the latter reverts to its normal condition. It will be sufficient here to give the following summary of the histological processes in question.

The first obvious change is dilatation of the arterioles, capillaries, and veins nearest to the blood-vessels whose divided mouths have been sealed by clot; and coincidently the rate of their blood-flow is quickened. These phenomena are followed by a slowing down of the local current, often to the point of stagnation, together with leakage of serous fluid and emigration of leucocytes into the surrounding connective tissue spaces in consequence of increased permeability of the altered vascular walls. This sero-corpuscular exudate undergoes partial coagulation with the formation of fibrin, and constitutes in the affected region a glue-like mass, continuous across the sides of the wound which are thus, so to speak, soldered together. Objectively to sight, the parts are rather more swollen and reddened, and to touch, warmer and firmer than in health. The cellular elements of the exudate become reinforced in number by the arrival of amœboid wandering cells, and also by the detachment and multiplication of fixed tissue cells. The important function of forming new connecting tissue appears to be mainly if not wholly performed by the last-mentioned group. They become fusiform or otherwise modified in shape, and put forth slender fibrils which blend with similar offsets from other cells in their vicinity; and as repair advances, the exudate is in this way penetrated by a network of delicate interlacing fibres stretching across the track of the wound and effecting organic union of its walls. Blood-vessels develop for the conveyance of pabulum to the young fibrous growth: they appear as buds jutting from the walls of capillaries, and elongate into protoplasmic cords with tapering ends, which unite with like processes from neighbouring capillaries so as to form arches; canalisation takes place, and circulation of blood is established through the anastomotic loops thus formed. Meanwhile the redundant portions of the exudate are removed: fluid is drained away by the absorbents, surviving leucocytes migrate—some perhaps laden with molecular particles of disorganised structures ingested by phagocytosis, and the fixed tissue cells further assist in the work of scavenging. With the roofing in of the surface by epithelium proliferated from the rete Malpighii, bordering on the edges of the wound, healing is complete, although the permanent condition of the fibro-vascular nexus—technically, the *cicatrix* or *scar*—is not attained for some months, during which gradual contraction goes on, leading to attenuation of the blood-vessels and shortening and condensation of the fibres.

2. *Healing by the Intermediation of Blood-clot.*—To a greater or less extent this mode of repair occurs in a large proportion of wounds united by first intention, inasmuch as small masses of coagulum collect in hollows and fissures opening from the cut walls; but it is seen in its typical form when a layer of clot of varying thickness separates the sides of a wound and prevents their close contact. Dendritic projections reach from the main mass into the divided blood-vessels, and the whole at first serves the useful purpose of a plastic cement supporting the wounded structures. Inflammatory exudation ensues upon the injury, and the exudate spreads as a thin coating between the clot and the tissues, whilst leucocytes and other migratory cells wander into the former, which now constitutes a matrix for the developing network of fibres and capillary loops. *Pari passu* with advancing tissue-genesis the blood-clot becomes decolorised and removed by disintegration and absorption of its corpuscles and fibrin. In the later stages epithelial cells restore the continuity of the surface.

3. *Healing under a Scab.*—In some cases where the margins of a wound are not actually touching, and the superficial stratum of exudate or blood-clot, or a mingling of both, dries up, the resulting crust is called a scab, and it may suffice to seal the aperture. Assuming that asepsis of the interior has been secured, the scab is a good barricade against bacterial infection later on; and under these circumstances union of the raw surfaces proceeds by first intention—quickly if the surfaces are touching, more slowly if there is an intervening clot. Epithelium grows across from the edges beneath the scab; and when the latter eventually falls off, the healed seam of the cicatrix is disclosed. When a dry crust covers the surface of a shallow wound made by superficial loss of substance, healing takes place by granulation, as described below.

4. *Healing by Granulation or Second Intention.*—Septic infection—a danger very likely to be met with in wounds of mucous membrane, and in accidental wounds generally, or those not carefully safeguarded against contamination—sets up a more energetic local reaction than is presented by the foregoing types, and is accompanied with a much greater amount of

tissue-degeneration. Under these circumstances recovery is somewhat delayed, healing being effected by the second intention, a comparatively slow process, exhibiting phenomena in which granulations play a conspicuous part.

In the first instance, the injury excites a traumatic inflammation, but the limits of this are widely transgressed by the irritation consequent upon the invasion of micro-organisms belonging to the class of pyogenic bacteria. Those usually found include the common varieties of staphylococcus (S. pyogenes aureus, S. pyogenes albus) and streptococcus (S. pyogenes); but it would seem that other fungi also possess the power of inducing, or at all events promoting, the formation of pus, *e.g.* the gonococcus, the pneumococcus, and the bacillus coli communis. Once securing a lodgment in the damaged structures, the bacteria are able to excrete peptonising agents, and to produce poisonous chemical compounds (toxins), which are extremely hurtful to the tissues exposed to their action. By a kind of digestion, fibres, cells, and intercellular substance are softened and more or less disintegrated and dissolved, the resulting degenerative products being washed out by the copious liquid exudate escaping from blood-vessels in the site of inflammation, many leucocytes being at the same time cast off. On the other hand, some of the toxic material may enter the general circulation and bring about constitutional disturbance. Locally, the discharge from the wound thickens, assuming the yellowish colour of pus, and suppuration is established. The constituents of pus comprise fluid derived from the blood and liquefied tissue, numerous leucocytes, some altered tissue-cells, necrotic particles of fibres and corpuscles, and pyogenic cocci; besides leucin, tyrosin, and peptone. As the stress of the attacking infection declines, the boundaries of the lesion are fenced off by a protecting barrier of leucocytes, and evidences of repair manifest themselves by the appearance of minute granular points, bright red in colour, studding the raw surfaces. These are the granulations characteristic of healing by the second intention. Each granulation consists of a newly-formed vascular loop arising from pre-existing capillaries, enveloped in layers of cells, of which the superficial ones are constantly being shed, whilst those in contact with the vessel are developing into fibres. As reconstruction advances, the granulations grow upwards and from the sides so as to progressively fill the gap, whilst beneath them fibro-vascular scar-tissue increases in quantity, contracting as it does so, and thus diminishing the wound in all its dimensions. With the approach of granulations towards the level of the skin, epithelium grows across from the edges, and surface continuity is restored.

5. *Healing by the Union of Granulations or Third Intention.*—When the opposite walls of a wound are lined with healthy granulations, and these are pressed into apposition, as by suturing, organic union may supersede the mere mechanical contact. The process by which interlacing fibres and capillary loops blend the two sides together is identical with what has been already described. Advantage can sometimes be taken of this mode of repair in order to hasten recovery when primary union has failed.

Summary.—From a review of the foregoing condensed account of healing, it is evident that the processes and their results are essentially of the same nature in all classes of wounds. Whatever mode of repair is investigated, the underlying feature, to which there is no exception, is inflammation, associated, as recoverable inflammation invariably is, with degeneration and generation of tissue. Traced to their foundation, therefore, the diverse phases of wound-repair are simply so many variations in the intensity of inflammatory reaction called forth by injury, whether that be mechanical violence acting alone or aggravated by harmful micro-organisms. In the case of primary union pure and simple, or one of its modifications of healing through a blood-clot or under a scab, disturbance is slight and reaction proportionately small, and in favourable examples the amount of new tissue constructed is almost infinitesimal; and whereas the contrary holds good for granulating wounds, yet after all the difference is merely one of degree rather than of kind, and the ultimate result is universally the same, namely the genesis of a fibro-vascular nexus, of which all scars in the soft parts are composed.

Immediate Treatment.—A. *General.*—The general condition of the patient will claim the surgeon's early solicitude. If there be much *shock,* the prompt administration of stimulants is indicated. This should take the form of hot stimulating fluids given by the mouth or rectum; or the injection of such drugs as ether, strychnine, digitalis and atropine under the skin. The hypodermic method will yield the most speedy results. The patient must be placed flat on his back with the head lowered by tilting up the foot of the bed on chairs; and warmth is to be promoted by blankets and hot-water bottles, care being also taken in cold weather to maintain the temperature of the room. *Anœmia* due to profuse bleeding demands the infusion of saline fluid into the subcutaneous connective tissue (hypodermoclysis). Normal salt solution 0·6 per cent warmed to 105° F. answers well, and as much as a pint may be allowed to flow into the chest-wall through a large hollow needle connected with rubber tubing and a glass funnel, the rate being kept slow by not unduly raising the funnel. Alternatively the fluid may be injected into the rectum. *Pain* should be quelled by morphia, which has the further beneficial effect in many cases of mitigating shock. In susceptible persons there is often a degree of *faintness* out of proportion to the extent of injury. The recumbent posture is here imperative, and indeed is advisable during the immediate treatment of all wounds. If the patient be seated, and syncope occur owing to painful manipulations or emotional disturbance, he may fall to the floor, to the confusion of the surgeon whose attention has been engrossed by the wound.

B. *Local.*—The paramount considerations to be kept in view from first to last are the securing of *asepsis* and *rest.* Of these asepsis is of supreme concern, but rest must also be regarded as absolutely essential to perfect success. If both conditions be efficiently maintained throughout, healing will take place quickly and satisfactorily with the slightest local changes, and, what is of vastly greater moment, constitutional disturbance with all its attendant dangers will be reduced to a minimum.

The technique of present-day wound-surgery and its scientific explanation are intimately related to the study of bacteriology,—particularly that branch which concerns itself with pathogenic organisms. The fact is now thoroughly established that many varieties of harmful bacteria abound in the air and dust of all places inhabited by man. They find favourable harbourage in the skin and mucous membranes, entering the mouths of ducts and penetrating between epithelial scales into the deeper layers of the epidermis, whence they can readily invade the vascular tissues through any breach of surface-continuity. All objects, other than germicidal agents, freely exposed to the atmosphere of populated districts become in like manner contaminated by the deposition of particles of dust or dirt, which to the surgical mind are merely synonyms for germs, and, commonly, pyogenic germs; and the contact of such contaminated objects with the raw tissues of a wound means infection. Thus clothing, sponges, water, lotions, instruments, ligatures, sutures, or dressings, if permitted to touch a wound without previous sterilisation, may give rise to most dangerous septic processes. Above all, the unpurified fingers of the surgeon or his assistants are liable to convey material into a wound with consequences no less fatal than those following the invasion of a bullet or bayonet into a vital organ.

A fundamental distinction must be drawn between wounds deliberately made by the surgeon through healthy integuments, and those arising from accident or assault. In the former group it is the bounden duty of the surgeon to adopt the most scrupulous precautions possible to ensure asepsis before, during, and after the operation. Not that complete sterilisation is certain to be attained by the means so far introduced, although it is the end to be strenuously pursued. The entrance of some germs into subcutaneous tissues freely exposed to air in its ordinary state is inevitable; but happily it is consistent with general experience that the presence of a small number of organisms introduced in that way does not prevent healing by first intention, always provided that the stringent rules of modern practice are faithfully followed. As to the propriety of seeking to remove or destroy these intruded bacteria by the application of an antiseptic, and, if thought appropriate, what antiseptic should be employed, surgical opinion is divided. The writer holds, with due deference to the views of others, that it is prudent, whenever extensive tracts are opened up in an operation, to apply a suitable antiseptic fluid to the cut surfaces before closing the wound; and for this purpose dilute izal lotion (izal 1 part, boiled water 800 parts) has proved satisfactory.

On the other hand, the surgeon is confronted with an altogether different set of conditions in the case of accidental wounds. Here there has been no preparatory disinfection, and therefore, having regard to the absence of prophylactic measures before the injury was inflicted, the only safe course is to assume, as a working rule admitting of very few exceptions, the existence of septic infection when the patient comes under surgical care. It is usually difficult, not seldom impossible, to overtake the initial disadvantages. The wound, soiled at the moment of its occurrence, may have been covered over by dirty wrappings, or, what is worse, meddled with by unprepared hands, carrying infection into its recesses. When, as frequently happens, the damaged parts are contused or lacerated, and still more when palpable foreign bodies have been ground in, the difficulties are immensely increased. But all this should not deter us from painstaking efforts to undo the mischief; on the contrary, it should be an incentive to the greatest nicety of detail in every step of the treatment, so far as the exigencies of any given case permit, in order that the conditions may be brought as closely as possible into line with those of a formal operation-wound. To this end it is essential that nothing but what is germ-free or germicidal should be allowed in or near the wound. In what follows it will be understood that accidental wounds are referred to, and the considerations stated above are assumed.

The requirements of local treatment comprise *hæmostasis, disinfection of the wound and its immediate surroundings, coaptation, drainage, dressing,* and *provision for rest and favourable circulation.*

1. *Hæmostasis.*—Bleeding is so pressing a danger when copious, and so much delays repair when allowed to go on even slightly within a closed wound, that the flow requires to be arrested at once and completely. The arrest may be natural or artificial. In either case the openings into the vessels become blocked by blood-clot or in other ways mechanically closed,

the blood-pressure being at the same time lowered; and the obstruction persists until permanent sealing takes place. Hæmorrhage from small vessels will stop spontaneously, or upon exposing the part to the air. For a wound of an extremity, elevation of the limb is a most valuable means of checking further loss of blood, the value of this method being the greater the more distal the wound. In the case of a hand the whole limb should be raised vertically by grasping uninjured digits, or supporting the elbow. For moderate arterial bleeding, digital compression of the main artery is indicated as a temporary measure until the vessels are secured. Profuse hæmorrhage from a limb can be promptly arrested by tying stout india-rubber tubing tightly round the limb at a higher level, first protecting the skin encircled with folded lint to prevent bruising. It is well to bear in mind that unless the ligature is firmly applied, the supplying arteries will not be fully controlled and oozing will continue from the wound. It is not uncommon to see free venous bleeding when an improvised tourniquet has been imperfectly placed above a wound by a well-intentioned bystander rendering first aid after the accident. Such bleeding will diminish or entirely cease on removal of the tourniquet.

As a general rule the wound must be widely opened and examined in a good light. The surfaces should be freely flushed with hot antiseptic lotion squeezed out of swabs of sterilised gauze, and all bleeding points can then be seized one after another with pressure-forceps—Spencer Wells' pattern or some modification. If any form of compression has been practised, this is cautiously relaxed, and visible vessels clamped until only oozing remains to be commanded, which is best done by gauze swabs. Ligatures, preferably of catgut, had better now be tied with reef-knots round the points grasped by the forceps, and these taken off; or torsion may be tried, but it is a less certain hæmostatic than the ligature. In some situations, for instance, near a bone, it may be necessary to underrun a vessel with a needle armed with catgut, which is then tied (suture-ligature); or a tenaculum hook may be required to draw up a bleeding point and render it more accessible. All ligatures are to be cut off short near the knot. Troublesome capillary oozing will often yield to the affusion of lotion or boiled water (to which common salt may be added in the proportion of one drachm to a pint), at a temperature of 115° F. Carnot's solution (gelatine 5 parts, calcium chloride 1 part, water 100 parts) has been recommended for the same purpose; and more recently preparations of adrenalin. Packing with a gauze tampon should only be resorted to when ligation is not available.

Incised wounds bleed much more freely than the contused and lacerated, as they are without the irregularities so conducive to coagulation possessed by the latter. In particular, deep punctures, as knife-stabs into fair-sized arteries, are often attended by most dangerous hæmorrhage. Every such case must be treated on its merits; in many it will be necessary to explore the track by making a free incision so as to reach the wounded artery, which is then to be tied both above and below the wound, and divided between the two ligatures if there is undue tension of that portion; in others it will be justifiable to rely on pressure without disturbing the clot which has, perhaps, already formed a more or less adequate plug, cases of this class being regarded as exceptions to the almost invariable rule requiring wounds to be opened up.

The indications for hæmostasis having been thus complied with, the wound is to be covered with a gauze swab while attention is given to the next step.

2. *Disinfection of the wound and its surroundings.*—This will repay the utmost care that can be bestowed. With the region well uncovered, first the area around the wound should be systematically and most thoroughly cleaned. Here the razor aided by soap lather is invaluable, not only on the hairy scalp, but wherever it can be applied, as it removes gross dirt together with the outer epidermal scales. The precaution should be observed of drawing the blade in planes parallel to the wound or away from it, so as to avoid carrying dirt up to the margins. After shaving (or if that be impracticable, without it), the surface is to be well scrubbed with soap and hot water, the brush having been previously boiled in 1 per cent sodium carbonate solution and kept ready for use in antiseptic fluid. Free ablution with boiled water will wash away traces of soap and loosened epithelium. Then follows brisk rubbing with methylated spirit on wool, commencing at the edges of the wound and working outwards in concentric rings, to get rid of fatty substances. Antiseptic lotion is to be douched over the purified area, which is then fenced off by towels as a safeguard against reinfection.

A word or two may be here interpolated as to the choice of antiseptic. Having regard to the fact that skilled workers, each employing a different chemical selected out of a large variety, can all point to equally successful results, it seems unquestionable that scrupulous observance of detail is incomparably more important than the actual substance employed. The ideal antiseptic has yet to be discovered. Intensely germicidal chemicals are irritants to the tissue-elements—though the harmfulness of this, so far as antiseptics of the strength in ordinary use are concerned, has perhaps been magnified, and at all events it is a far lesser evil than sepsis. After several years' ample experience of izal in the casualty department of the Queen's Hospital, Birmingham, the writer can speak very favourably of this substance in the treatment of accidental wounds. He prefers it as the antiseptic for routine purposes on the following grounds:—(i.) it is a powerful germicide; (ii.) it is not poisonous if absorbed; (iii.) it is less irritating to the tissues than some of its chief rivals; (iv.) it does not tarnish instruments; (v.) it is not costly. For recent wounds a dilution of 1 part izal to 800 parts of boiled water may be used; in suppurating cases and for application to the skin, double or treble that strength is indicated.

Turning now to the wound itself, this must be dealt with according to the conditions met with. There may be a simple incision or any gradation of wound up to an extensive laceration whose ragged surfaces are begrimed with grease from machinery or road-dirt which has been ground into the tissues by a cart-wheel. The merest bathing will suffice for the former; whereas the latter demands thorough-going measures, which can only be adopted, speaking generally, after the patient has been anæsthetised. The first essential in every case is to remove all extraneous matter. Defined and fairly loose foreign bodies, *e.g.* hair, grit, glass, straw, mud, can be removed by means of forceps, sharp spoon, and swab, supplemented by liberal douching; grease and embedded particles will need the careful employment of hand-brush and soap; dirt still more ingrained can only be cleared away at the sacrifice of some tissue by the judicious use of scalpel and scissors. The danger lurking in partially concealed spaces is to be remembered, and the wound enlarged when necessary and the roof of any undermined tract laid open, in order to fully expose the whole of the interior and its recesses. Only in this way can sufficient access be gained to ensure thorough disinfection. Tags of skin or fat hopelessly damaged by crushing or detachment should be cut away, since they will necrose if left.

All bleeding having been finally arrested, the whole of the wound is now to be washed over with antiseptic lotion as completely as possible, no part escaping attention. The good effect of this is largely due to the mechanical removal of germs and débris, but there must also be added the undoubted power of the antiseptic to destroy, or short of that, inhibit germ life. Following ablution, the parts are to be dried with gauze swabs.

3. *Coaptation.*—The closure of accidental wounds is apt to be overdone. It is much better to err on the side of doing too little than too much in this direction, even at the cost of some delay in healing. The majority of cases are furnished by the contused and lacerated varieties, and in many examples of these there are fragments of tissue bound to perish, whilst all of them contain parts so devitalised by traumatism that they can offer little or no resistance to pyogenic bacteria. Besides the admitted uncertainty of effecting absolute sterilisation, the risks of further infection are multiplied by a patient's lack of care and knowledge, together with the uncleanly circumstances of the poorer class; added to which there may be constitutional or local conditions prejudicial to quick repair. Hence, except in a richly vascular region like the face, it is seldom advisable to entirely coapt the edges, lest septic products should get shut in.

Within the wound the ends of any divided tendon or important nerve should be sought for and accurately stitched together,—with catgut, if there is reasonable prospect of speedy healing, otherwise with silk, as likely to hold longer. The search for the retracted proximal end of a tendon is not always an easy matter, and will often involve an extension of the wound: relaxation of the parts will here prove helpful. Cut muscle also should be sewn, but unless the division is complete a point of suture here and there will suffice. Wherever practicable, successive planes of divided tissue should be reunited in their proper layers by buried catgut sutures—muscle to muscle, fascia to fascia, skin to skin.

The question of coaptation may be summed up in the general statement that, as a rule, incised wounds should be closed, all others left more or less open. In the worst lacerations the idea of primary closure cannot be entertained: all that can be done is to fill the gap with a light packing of gauze and await the arrival of conditions favourable to secondary closure. The surgeon will exercise his discretion in dealing with the many intermediate forms of wound between those which may safely be brought into exact apposition and those which must be treated by the open method. Undue tension must always be avoided; it is certain to be followed by cutting through of the stitches, or death of the stretched flap,—as, for example, in the common case of a triangular flap of skin torn down a limb away from its blood-supply.

Suturing is the most suitable way of drawing the edges into contact. The interrupted method is to be preferred to the continuous, because the stitches are more independent, and one or two can be removed without disturbing the rest if it should become necessary to reopen part of the wound. The smooth and non-absorbable silkworm-gut, horse-hair, and silver wire, are the best suture materials for this purpose. Many wounds can be adequately closed by the pressure of dressings alone. Adhesive strapping is sometimes useful: it should be cut narrow in the middle and with broad ends (fiddle-shaped), so as to take firm hold of the skin on either side of the wound, and the latter should be covered with a strip of gauze to prevent the bridge of strapping from actual contact with the line of union. Or the gauze may be applied transversely, one end fixed with collodion, the margins of the wound approximated, and the other end of the tense gauze similarly fastened to the skin. Metallic clips without sutures have also been recommended.

4. *Drainage.*—Exudation of sero-albuminous fluid occurs in every wound, the quantity varying with the extent and characters of the injury. The absorption along lymph channels into the blood of fluid and other products of traumatism (notably fibrin-ferment, or, according to Schnitzler and Ewald, nucleins and albumoses), gives rise to the phenomena of simple (aseptic) traumatic fever. Moreover, the exudate, in virtue of its composition and temperature, is a pabulum highly favourable to the growth of pyogenic bacteria, and with their inoculation into the wound inflammatory reaction is greatly intensified, fluid exudes more copiously, and toxins are produced. Septic intoxication (sapræmia) results from the absorption of those chemical compounds, whilst locally the clinical evidences of inflammation manifest themselves and the wound undergoes retrogressive changes. The still more dangerous systemic phenomena of septicæmia or pyæmia follow the onset of suppuration if associated with the transmission of bacteria, alone or mingled with putrefying particles, into the blood-stream. The more abundant the secretions, provided there is no exit by which they can escape externally, the greater will be the tension about the wound, and consequently the more readily will constitutional infection ensue; added to which, if the patient survive the dangers incurred, there may be considerable damage to structures in the region of the wound, resulting in permanent loss or impairment of function. Further, the tension and other evils will be augmented if any bleeding goes on owing to imperfect hæmostasis.

It will be gathered from the foregoing data that, whilst exudation is an inevitable concomitant of wounds, retention of the products is always harmful, and the supervention of sepsis may imperil or destroy life. Hence it is imperative to minimise the secretions, protect them from bacterial infection, and facilitate their rapid escape. In the simplest cases of clean incised wounds whose walls can be brought into exact apposition, exudation is so insignificant that it may in practice be disregarded. At the other extreme of the series are the cases in which the most inexperienced will see the obvious necessity for providing wide drainage channels. For the rest it will be wise to apply the prudent aphorism, "when in doubt, drain." The simplest mode of doing this, supposing a wound in which it has been decided to insert sutures, is to leave the dependent angle open so that it may act as a natural drainage outlet. Artificial drainage may be effected in various ways; the objects they all have in common are to establish a route from the interior to the surface, and insert along it a conductor intended to guide discharges out of the wound. The fullest advantage must be taken of gravitation by arranging that the outlet shall be at the lowest point, the position of which will be determined by considerations of posture. Thus it will sometimes be requisite to make a counter-opening at a distance from the wound-edges for the easy drainage of a low-lying pocket,—for instance, where a large flap of scalp is torn down from the vertex. India-rubber tubing, introduced to surgical practice for this purpose by Chassaignac, is a valuable appliance for wound-drainage. Holes are made at intervals in the wall of a vulcanised tube of suitable calibre and length, and this is lodged in the wound so as to meet the requirements of any given case. For easier insertion the inner end may be cut obliquely to a point; the outer end should barely project beyond the surface, like a short spout, to avoid kinking or occlusion by the dressing, and may be prevented from slipping in or out by stitching it to one border of the wound with a single suture,—though, in general, only the former accident needs safeguarding, and this can be done by the simple device of transfixing the mouth of the tube with a safety-pin. Decalcified bone tubes are sometimes used instead of rubber. Most efficient drainage can be ensured by means of strips of gauze (cheese-cloth), which may be plain, or impregnated with an antiseptic, *e.g.* izal or iodoform. This material acts by capillary attraction, fluids being drawn from the interior and delivered into the dressings. In wounds designedly kept open, the gauze should be brought by light packing into contact with the greatest possible extent of the raw surfaces, in order to secure the rapid withdrawal of every drop of discharge. The increasing employment of capillary drainage in surgical work is tending to restrict the use of tubing, but the latter is undoubtedly of great advantage where the discharge is thick or has to be drained through a long fistulous track. A combination of both methods is often very serviceable, a tube being passed to the bottom and surrounded by gauze; or conversely, a wick of gauze may be threaded through an ensheathing tube,—a plan which facilitates subsequent removal of the drain. For a shallow wound, or one with walls but little separated, a narrow strip of gutta-percha tissue or green protective answers well. Satisfactory drains can also be made by knotting together a few strands of catgut or horse-hair: these can be readily placed in position with a probe or sinus forceps.

5. *Dressing.*—The objects in view here are to defend the wound against fresh infection, to absorb any discharges, and to maintain such a degree of equable pressure as will check oozing, obliterate "dead spaces," and generally support and protect the injured parts. Before applying the dressings it is well to finally cleanse and dry the skin around the wound, and then to squeeze out the last drops of moisture (blood, serum, or lotion), and to maintain the compression as the successive layers of material are applied. For the innermost dressing there is nothing better than gauze,—plain or charged with an antiseptic, *e.g.* izal, iodoform, double cyanide of mercury and zinc (Lister). This should well cover the wound, and a circular mound of it should surround the drain-exit, at which point more gauze is to be placed than elsewhere. Next follows a liberal supply of absorbent cotton-wool, a good form of which is the Gamgee-tissue introduced by the late Sampson Gamgee. This must extend well beyond the wound in all directions, as otherwise slight displacement would leave the part unguarded. It is often advisable, especially in the case of children, to fix the inner layer of wool to the skin by brushing collodion over its margins; or where extra support is desired, straps of adhesive plaster are most useful, and are strongly to be recommended in wounds of the abdominal wall, the strapping being cut broad and long. Unless the wool is sufficiently abundant, soakage through may occur and establish a path for infection, but the danger can be lessened by using an antiseptic wool, a course which should certainly be followed when copious exudation is expected. Waterproof material, as jaconet and gutta-percha tissue, placed outside the absorbent wool to intercept discharge coming through and turn it laterally, is not so much employed as formerly. The writer has found non-absorbent (fatty) wool useful for this purpose, and its employment is strongly advocated by Bloch of Copenhagen: it should of course be sterilised by heat. But the far safer plan is to promptly change the dressings that are soaked through. Lastly, to secure the other materials in position, and to exert through them the amount of pressure suitable for the particular case, bandages are applied. Domette is a satisfactory material for ordinary purposes; but where lightness is a desideratum, on the scalp for instance, gauze is to be preferred; and if unusual pressure is wanted in any situation elastic webbing is excellent.

6. *Provision for Rest and favourable Circulation.*—Unless wounded structures are maintained in due approximation, quick and firm union is impossible; and since mechanical disturbance, arising from muscular action or imparted from without, alters the relations of wound-surfaces, it inevitably tends to retard healing, and it may even undo what has been already gained in that respect. Moreover, it augments local irritation, and thus intensifies inflammatory reaction, with the consequence that the escape of fluid and cells is more rapid and abundant. If at the same time the covering dressings are displaced, the wound becomes an easy prey to infection. On various grounds, therefore, unrest is extremely prejudicial to repair, and must be prevented. The chief means to this end are posture, splints, slings and bandages; and these should be intelligibly made use of to meet the requirements of any case, according to the region injured and the special features of the wound, so as to secure the maximum of repose combined with enough relaxation to avoid tension. Confinement to bed is an ideal measure, but it is seldom available or submitted to except for moderate wounds of the lower extremity or severe ones in any situation. Besides saving the patient from undesirable movements, it moderates physiological activity in general, and conduces to regularity of blood-supply by keeping the cardiac rhythm uniform.

Closely connected with the consideration of rest are questions relating to the circulation. Retardation of the current in veins and lymphatics will seriously interfere with repair by inducing venous congestion and œdema. The utmost care must therefore be taken to avoid undue constriction or compression by bandages and splints. The omission of this precaution will also entail the risk of obstruction to the arterial supply, the effect of which would be starvation of tissues and probably gangrene of larger or smaller portions,—in particular, torn and contused fragments already seriously devitalised would certainly perish. Where the wound is situated in an extremity, elevation of the limb on an inclined plane sloping downwards to the trunk will promote rapid healing, combining as it does quiescence of the parts and most favourable conditions of circulation.

After-Treatment.—(A) *General.*—The reparative process is extremely susceptible to influences prevailing within and around a patient. In the busy routine of hospital out-patient practice these influences do not always receive the attention their great importance deserves, and in attending to details of dressing the surgeon may lose sight of that wider aspect of wound-treatment which may be expressed by the proposition that the growth of reparative tissue is subject to conditions governing the growth of normal tissue in childhood. Healing is powerfully influenced for good by such hygienic conditions as fresh air, sunshine, cleanliness, nourishing food, warmth, and cheerful surroundings, their combined effects being to invigorate the functions of nutrition, and fortify the resisting power of the tissues against noxæ of all kinds. The readiness with which wounds will heal under favourable climatic conditions was strikingly illustrated in the recent South African campaign, the bright dry atmosphere to which the wounded were freely exposed benefiting the mental state as well as the physical. Too much stress cannot be laid on the value of a plentiful supply of fresh air. It is not only a prime necessity for enriching the quality of the blood, but it also dilutes and removes deleterious substances given off from the patient's body or accumulating around him from other producing sources.

The digestive system should be looked to. An accidental injury abruptly changes the habits of a patient's life, and the effects of the transition from full work to comparative inaction need to be thoroughly appreciated.

It is a safe rule to give a dose of calomel and a saline purgative, partly for the sake of lowering the blood-pressure, but mainly to unload the bowels of effete material, the retention of which might lead to absorption of noxious substances (auto-intoxication), and thereby render the tissues more vulnerable to bacteria. While the patient is debarred from active muscular exercise he will require less food, especially animal meat, than a healthy person, *cœteris paribus.* The diet should consist of simple nutritious food-stuffs adapted to the digestive powers, and variously modified to meet any special indications. Alcohol is usually quite unnecessary, and had better be forbidden: in many cases it is responsible for the making of the wound and for concomitant digestive derangement, as well as other well-known complications which will demand appropriate treatment. In fine, the state of the stomach and other digestive organs should in no case be neglected.

When recovery from the anæmia attendant upon severe hæmorrhage is tardy, iron should be prescribed, and with this drug strychnine may sometimes be usefully combined.

Recognising the therapeutic value of contentment and cheerfulness, the surgeon will not overlook the importance of pleasant surroundings and genial influences in general.

(B) *Local.*—The redressing of wounds must be conducted on the same lines as the original treatment, the parts being fenced off with sterilised cloths, and no rule relating to the disinfection of hands, instruments, and materials, relaxed. Exposure of the wound should also be as brief as possible. Assuming that asepsis has been secured in the case of a wound almost or quite closed, the dressings need not be changed for some days, since only harm can come of premature disturbance and uncovering: at the end of a week healing will have taken place, and stitches may be removed, dry gauze then being applied for a few days longer whilst the scar is consolidating.

Earlier attention will be required in various circumstances. Thus the appearance of discharge soaking through within twenty-four hours must be promptly met by packing over the spot a pad of absorbent wool secured by light bandaging; and it is advisable to change the whole dressing not later than the next day. Drainage tubes, too, should as a rule be taken out, and if the wound is satisfactory, left out, at the end of the first forty-eight hours. The onset of local pain or general febrile symptoms will also demand early examination of the wound; if, as is very probable, the trouble is due to pent-up exudate, this must be relieved by taking out one or more stitches and putting in a drain through a track made in the lower angle by a pair of sinus forceps or a director. Again, when a wound has been kept open by the free insertion of gauze, this should be withdrawn by gentle traction on the second day, and replaced by fresh gauze: to avoid bleeding, any very adherent portions of the material may remain a day or two longer.

So long as the wound shows no infective changes, a dry dressing is preferable. But if active inflammation ensues there must be no delay in freely opening up closed surfaces by cutting the stitches, and establishing a wide exit for discharges, which may be efficiently drained away by strips of gauze packed lightly within the wound and leading externally to layers of the same material wrung out of lotion. It is necessary to change wet dressings of this kind twice a day or oftener whilst suppuration is copious, if the septic condition is to be speedily checked. Whenever feasible, immersion of the wound and inner gauze in a bath of weak antiseptic has great advantages: it renders removal of the packing easier and less painful, and enables the lotion to penetrate into the recesses of the wound, where it displaces and dilutes the toxic substances. For cleansing infected parts that do not admit of immersion, irrigation under low pressure is serviceable, but forcible syringing must never be permitted. Continuous irrigation is sometimes of great value, the fluid being delivered as a slow stream flowing from a wick of gauze or worsted in contact with the highest point of the wound, the other end of the wick dipping into an elevated reservoir of lotion. Several precautions are to be taken,—the fluid must not splash upon the wound from a height, it must be kept warm, and it must be unirritating; normal salt solution answers the purpose very well.

With the decline of intense inflammation in a wound that has suppurated, the walls become covered with healthy granulations: these should now be purified as much as possible, and the opposite surfaces drawn together in order to hasten repair by secondary closure.

Such complications as stitch abscesses, sloughing of damaged tissues, and cellulitis, must be dealt with on the lines already laid down, the aim in all cases being the prompt and complete removal of harmful substances from the wound and its surroundings. It may be added that, in dressing septic wounds, the surgeon will find rubber gloves a great protection to his hands.

Wrist-Joint Injuries.

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CONTUSIONS of the Wrist Joint and its neighbourhood are not uncommon, but most frequently fractures of the bones, either of the fore-arm or the carpus, result from them, and monopolise the attention of the surgeon.

In discussing certain of these fractures presently I shall consider contusion in some detail. Generally speaking, the covering of the bones is so closely adherent to them, and of so little thickness, that in simple injuries the contusions of the soft parts attract but little attention; in compound injuries the question of their vitality is of all importance in the determination of the treatment to be adopted in each particular case, whether it should be expectant, amputation, or excision.

In rare cases of contusion by soft and heavy bodies the bursal sac which invests the flexor tendons beneath the anterior annular ligament, and extends far above and below the limits of the ligament, suffers injury, and develops a traumatic bursitis, usually of moderate intensity, which yields in a short time to treatment by rest and cold lotions.

In former times, before the confidence in the safety of antiseptic surgery was developed, it used to be the daily practice to treat the tumour known as ganglion by a blow from the back of an octavo book with firm, smooth leather binding, and so to burst the cystic tumour and extravasate the fluid contents in the tissues around the tendon sheaths. This treatment, rough and ready, was in the majority of cases successful. I have, however, seen instances where, either from excessive force of the blow, or because the constitutional condition of the patient was unsuited to resist the effects of such injury, inflammatory troubles have followed, and have led even to the loss of the limb. A clean needle or tenotome in these days effects a more gentle and a safer division of the walls of these cysts.

The statistics of the medical and surgical history of the War of the Rebellion (1861-1865), American, are the most reliable that we can examine as a guide to the treatment of gunshot injuries of the wrist. In this war "the large majority of cases was treated by expectant conservative measures, with a comparatively low rate of mortality," 716 cases out of a total of 1496, or very nearly one-half, treated on expectant lines yielded a mortality of 7·9 per cent.

"To moderate inflammation by cold applications, by ice-dressings when available, to support the parts without constricting, bandaging upon a padded splint, to relieve inflammatory tension by free incisions as soon as suppuration took place, to remove all splinters and detached fragments, and, finally, to institute passive movements of the fingers and hand at the earliest practicable moment, were the practical indications that were chiefly insisted on in the expectant conservative treatment of shot-fractures of the wrist." On the other hand, excision of the wrist recorded in 109 cases gave a mortality rate of 13·7 per cent; and again, amputations at the wrist for shot-injury gave as a result a death-rate of 10·6 per cent. In these days, with an antiseptic treatment efficiently carried out, and probably still of greater importance, with wounds inflicted by the bullets of modern warfare, conservative expectant treatment must be attended with even more favourable results, and the operations of excision and of amputation should show a proportionate decrease of mortality.

Dislocation of the wrist from injury is universally admitted to be extremely rare, but to be an injury which has real existence.

Writing in 1814 at the close of his short and original description of fracture of the lower end of the radius, Colles says: "During the last three years I have not met with a single instance of Desault's dislocation of the inferior end of the radius, while I have had opportunities of seeing a vast number of the fracture of the lower end of this bone."

We find in the lectures of Dupuytren published some twenty years after the writing of Colles, which we have quoted, the following as the mature opinion of the great French surgeon :—

"Without denying absolutely the possibility of the dislocation backwards of the radio-carpal joint, although I have never met with it, one must admit, at least, that it is excessively rare, and that perhaps it never exists in consequence of a fall on the anterior part of the wrist."

When we read the writings of Desault, Boyer, and even Dupuytren, the difficulty that first meets us is the meaning that they attach to the term dislocation of the wrist. Is it dislocation of both radius and ulna from the carpus, or is it dislocation of the radius only or of the ulna only?

While each of the varieties here enumerated has been proved to exist, the actual number of possible dislocations must be increased by the varieties backwards and forwards, and possibly more. One must always bear in mind that dislocations uncomplicated by any fracture of the bones of the fore-arm or of the carpus are the rarest of all.

One of the very first to question the correctness of the assertion of Dupuytren, which would induce us to banish true dislocation of the wrist from the list of surgical casualties, was Voillemier. He says: "But still there is nothing else but the immense authority of this man, a species of fanaticism with which one accepts his thought to set aside in one day the traditions of L. Petit, of Desault, of Boyer. We are obliged to admit that these great masters of surgery, who have shown so much exactness in their observations, so much right sense in their judgments, and a spirit so simple in their descriptions, had all fallen into the same error, and have given the signs of a malady that they have never seen. Instead of waiting till facts could decide this question, an exaggerated enthusiasm, without appeal, judged it, and taxed as heresies all independent spirits who did not accept as an axiom the opinion of the surgeon of the Hotel Dieu."

With these observations Voillemier introduces his account of an accurately dissected dislocation of the wrist backwards. The category of such cases has grown since 1839, when Voillemier published his case. Some seventy fairly authenticated cases are now recorded, the greater number backward dislocations. Of the forward dislocations seven at least have been proved by dissection.

I have never seen a recent traumatic dislocation in the living or dead; our collection contains no instance of the lesion except in association with fracture of the radius. I shall now quote an excellent description of the complete dislocation of the carpus:—

Dislocation of the Wrist.[1]—W. W., aged twelve, was admitted 22nd March, having been knocked down by a cart a short time previously. He had two lacerated wounds of the scalp, and in connection with one of them a linear fracture of the posterior fossa of the base of the skull. There were no symptoms of brain injury. He complained of pain in the left wrist, but the parts around were so much swollen that the nature of the injury could not be made out. There were, however, two slight transverse abrasions on the fore and outer part of the limb about half an inch above the wrist joint. Evaporating lotions were applied and the swelling gradually diminished. The part then presented the following characters:—The whole of the hand was *displaced forwards* and slightly outwards; on the dorsal aspect of the limb the lower end of the radius and ulna formed a marked projection, the styloid processes, especially that of the radius, being very prominent, and the concave margin of the latter bone easily traced between them; anteriorly a somewhat pointed prominence could be felt in the middle line opposite the wrist joint. The deformity was easily removed by slight extension, but returned again almost immediately. There was no crepitus. Two straight splints were applied to keep the parts in position. On the eighth day after the accident the patient was seized with tetanus and died the following day.

Dissection of the Wrist.—The parts about the joint were much ecchymosed. The external lateral ligament was completely torn through. The anterior ligament was torn from its attachment to the scaphoid and semilunar bones, and presented a free border inferiorly between the styloid process of the radius on the outer side, and the cuneiform bone on the inner side—the ligaments uniting the semilunar to the cuneiform were torn through; the scaphoid and semilunar, carrying the hand with them, were displaced forwards, passing over the free border of the anterior ligament, which ligament came thus to intervene between these bones and the surface of the radius with which they articulate; the cuneiform was not separated from its connections, except those with the semilunar, and maintained its normal relations to the ulna and fibro-cartilage, though this part of the wrist joint was in a state of considerable flexion.

Remarks.—This was a case of pure dislocation; there was no fracture of any of the bones, and no separation of the epiphysis of the radius. No clue could be obtained as to the direction of the force producing the dislocation, except from the position of the abrasions mentioned above, which seemed to indicate a force acting anteriorly on the lower end of the radius. The speedy return of the displacement observed was manifestly due to the fact that the dislocation was never really reduced, owing to the bones having passed in front of the anterior ligament of the wrist joint. The pointed prominence observed on the anterior aspect of the limb during life corresponded to the projection forward of the semilunar bone.

Very recently the following concise and graphic account of a compound dislocation of the bones of the fore-arm forwards without any fracture makes the recognition of such injury essential, and is noteworthy for the success of its treatment.

A Case of Compound Dislocation of the Wrist.[2]—A young man in emptying a cart of coal was lifting up the front end of it, when the horse quickly plunged forwards, whereby the weight of the coal and the moving cart was thrown with great force upon the palm of the right hand; as the elbow was fixed on the shaft a compound dislocation of the wrist resulted.

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[1] *Lancet*, 29th June 1878. Mr. Goodall's case, Birmingham General Hospital; recorded by Mr. Howard Lowe.

[2] *British Medical Journal*, 1st October 1898.

When I saw the case I found the lower ends of the radius and ulna partially denuded of periosteum projecting 4½ inches into the palm of the hand. There was great hæmorrhage and considerable laceration of muscles and ligaments. The lower end of the radius and ulna were, in fact, stripped of all muscular and ligamentous attachments, and looked as if they had been scraped.

The parts were washed well with a strong solution of creolin and the dislocation reduced under chloroform. The lacerated and torn muscles, nerves, and tendons were brought together with catgut and the skin sutured. Free drainage was provided for, and the parts well dusted with boric acid and dressed with carbolised gauze, and the whole arm put into splints.

The parts healed by first intention, and at the end of three weeks massage and passive movement were regularly persevered in with the happiest results—a perfectly movable joint with no deformity.

Newcastle-on-Tyne. Wm. Tiplady, L.R.C.P.E.

I quote these examples to prevent any error arising in the mind of any of my readers as to the reality of uncomplicated dislocations of the wrist joint.

The Fractures of the Bones of the Fore-arm

in the immediate neighbourhood of the wrist joint may be arranged as follows:—

Colles' fracture.
Colles' fracture reversed.
Epiphysary separation.
Fracture of the radial styloid process.
Longitudinal fracture of the lower end of the radius.
Fracture of the ulnar styloid.

Colles' fracture is commonly caused by a fall on the outstretched hand in walking or running; in falls from greater or less heights it occurs from the individual lighting on the hand or hands: in such falls as, for example, from the rigging of a ship to the deck.

I have seen the radii broken symmetrically. I have seen the injury symmetrical, too, as the result of the following accident:—A man was helping at the taking down of a builders' scaffolding; as he reached up his open hands to receive a heavy scaffold pole which was being lowered horizontally, the rope which let down the pole was suddenly let go when the pole was almost in his grasp. The sudden blow to the wrists broke the radii of both fore-arms. Again, I have seen the injury caused in one fore-arm thus: A surgeon driving in a low phaeton sought to save his knees from the kicks of his restive horse. To do so he stretched his arm and hand to lean on the leather dash-board of the carriage while he withdrew his knees as far as possible: in this attitude the horse struck the dash-board opposite to the point where the surgeon's palm rested. A Colles' fracture was the result. It is quite easy to produce the fracture in the dead body after the manner of Nelaton, experimentally, by sawing off the upper end of the ulna, disarticulated from the humerus, flush with the upper surface of the head of the radius. If the hand be placed prone on the table in full extension at the wrist, and a smart blow is struck with a mallet on the section of the ulna and the head of the radius simultaneously the fracture takes place. In these varied ways the fracture which results in the living or the dead is seated within half an inch or thereabouts transversely in the radius above its carpal surface. In some examples the fracture may incline with slight obliquity from the dorsal to the palmar surface of the bone. One point is, I think, fully proved by the examination of a large collection of specimens which I have before me (120), that the break in the bone is never found to be as remote from the carpal surface as Colles located it. "This fracture takes place at about an inch and a half above the carpal extremity of the radius."[1] In making this statement Colles was probably led astray by mistaking the site of the springing of the dorsal tumour of the deformed wrist for the site of the fracture. At the time he wrote (1814) he had made no dissection of the injury.

Except in this one matter his account of the injury is unrivalled:—"The posterior surface of the limb presents a considerable deformity, for a depression is seen in the fore-arm, about an inch and a half above the end of the bone, while a considerable swelling occupies the wrist and metacarpus. Indeed, the carpus and base of the metacarpus appear to be thrown backward so much as on first view to excite suspicion that the radius has been dislocated forward. On viewing the anterior surface of the limb we observe a considerable fulness, as if caused by the flexor tendons being thrown forwards. This fulness extends upwards to about one-third of the length of the fore-arm, and terminates below at the upper edge of the annular ligament of the wrist.

"The extremity of the ulna is seen projecting towards the palm and inner edge of the limb; the degree, however, in which this projection takes place is different in different instances. If the surgeon proceed to investigate the nature of this injury he will find that the end of the ulna admits of being readily moved backwards and forwards. On the posterior surface he will discover by the touch that the swelling on the wrist and metacarpus is not caused entirely by an effusion among the softer parts; he will perceive that the ends of the metacarpal and second row of the carpal bones form no small part of it. This, strengthening the suspicion which the first view of the case had excited, leads him to examine, in a more particular manner, the anterior part of the joint, but the want of that solid resistance which a dislocation of the radius forwards must occasion forces him to abandon this notion, and leaves him in a perplexing state of uncertainty as to the real nature of the injury; he will, therefore, endeavour to gain some information by examining the bones of the fore-arm. The facility with which (as before noticed) the ulna can be moved backward and forward does not furnish him with any useful hint. When he moves his fingers along the anterior surface of the radius he finds it more full and prominent than is natural; a similar examination of the posterior surface of this bone induces him to think that a depression is felt about an inch and a half above its carpal extremity. He now expects to find satisfactory proofs of a fracture of the radius at this spot. For this purpose he attempts to move the broken pieces of the bone in opposite directions; but, although the patient is by this examination subjected to considerable pain, yet neither crepitus, nor a yielding of the bone at the seat of fracture, nor any other positive evidence of the existence of such an injury, is thereby obtained. The patient complains of severe pain as often as an attempt is made to give to the limb the motions of pronation and supination. If the surgeon lock his hand in that of the patient and make extension, even with moderate force, he restores the limb to its natural form, but the distortion of the limb instantly returns on the extension being removed. Should the facility with which a moderate extension restores the limb to its form induce the practitioner to treat it as a case of sprain, he will find, after a lapse of time sufficient for the removal of similar swellings, the deformity undiminished. Or, should he mistake the case for a dislocation of the wrist, and attempt to retain the parts *in situ* by tight bandages and splints, the pain caused by the pressure on the back of the wrist will force him to unbind them in a few hours; and if they be applied more loosely, he will find at the expiration of a few weeks that the deformity still exists in its fullest extent, and that it is now no longer to be removed by making extension of the limb. By such mistakes the patient is doomed to endure for many months considerable lameness and stiffness of the limb, accompanied by severe pains on attempting to bend the hand and fingers. One consolation only remains, that the limb will at some remote period enjoy perfect freedom in all its motions, and be completely exempt from pain; the deformity, however, will remain undiminished through life. . . . Let the surgeon apply the fingers of one hand to the seat of the suspected fracture, and locking the other hand in that of the patient, make a moderate extension, until he observes the limb restored to its natural form. As soon as this is effected let him move the patient's hand backward and forward, and he will, at every such attempt, be sensible of a yielding of the fractured ends of the bone, and this to such a degree as must remove all doubts from his mind."

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[1] *Edinburgh Medical and Surgical Journal*, vol. x. 1814, p. 183.

Such is the description of the injury as Colles gives it. After an interval of some twenty years Dupuytren published his account, evidently without knowledge of the previous description of Colles, and suggests the fracture by crushing of the lower fragment as the leading type of the injury.

Every surgeon admits, I believe, the value of the researches of Professor R. W. Smith and of Voillemier in the pathology of these injuries, which have served to correct and complete the descriptions of Colles and of Dupuytren.

Since their views have been published we find authorities ranging themselves on opposite sides, according as they adopt the non-impaction theory of Smith, or the opposing doctrine of Voillemier, that all these injuries are fractures by penetration. Of late the number of recent dissections have forced most writers to admit the occurrence of each form. We have ample proof that the simple transverse fracture without impaction, the impacted, and the fracture *par écrasement* with a shattered lower fragment, are all possibilities. Intimately connected with the theory of impaction is the explanation of the variability of the symptom so much relied on in the diagnosis: crepitus. Yet any one who will take the trouble to investigate the statements contained in the accounts of recent cases which have been submitted to dissection may find that this symptom has been absent in each form of the injury. We cannot, therefore, rely on its absence as the proof of the existence of impaction in any given case, nor are we for the same reason to abstain from attempting reduction of the deformity for fear of undoing the impaction, or again rely on it as a safeguard against displacement, and so adopt a lax treatment.

In the study of the pathological varieties of the fracture one must be struck,

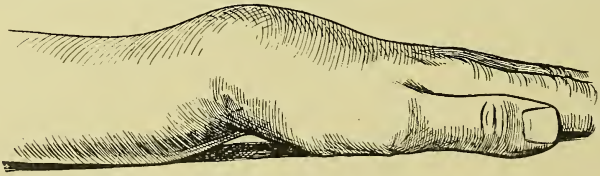

FIG. 1.—From a cast of an ordinary Colles' fracture.

in the examination of a large series of specimens, with the differences in the degrees and kind of displacement presented by individual cases.

Clinically the same varieties are observable. In the ordinary run of cases the diagnosis based on the familiar inverted spoon deformity (Fig. 1) is easy, so that to these cases the description of Pouteau applies: "There is, perhaps, no fracture more easy of recognition at a simple glance." The words of Voillemier in his reference to the examples which occur with little or no deformity are worth notice: "But one must be forewarned that in certain cases—and these are not very rare—of penetration but little marked, fractures by tearing of the bone *par arrachement*, it is possible that there may be no change in the axis of the limb, no shortening, no mobility between the fragments, no crepitation, and only pain and swelling around the wrist; in fine, all the symptoms of a sprain."[1]

Here the author admits a group of injuries sufficiently common, in which impaction is absent or inappreciable—in which, too, crepitus and deformity are absent. If such cases be overlooked, as they too commonly are, the most extreme deformity establishes itself in a short time, as I have more than once observed. These facts are certainly inconsistent with the theory that deformity, the result of displacement, is solely due to impaction, and that muscular action takes no part in its production.

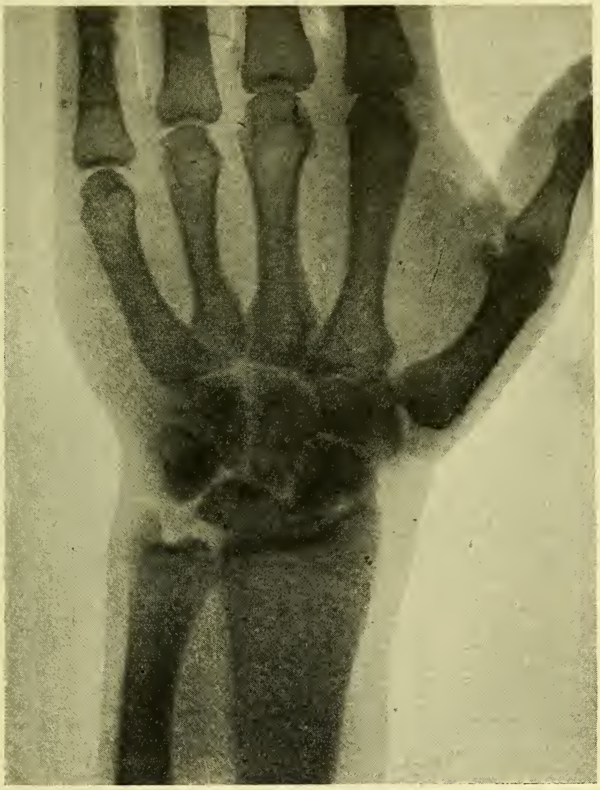

Fig. 2.

In opposing Voillemier's views Smith falls into the opposite error, in almost absolutely denying the occurrence of impaction. He says: "I am inclined to believe that the doctrine of fracture with penetration is untenable." He says, indeed, in another passage: "Until, therefore, the result of the examination of recent specimens can be adduced in support of the theory, I shall be inclined to believe that impaction is only apparent."

The photograph (Fig. 4) of the specimen on which Professor Smith based his rejection of Voillemier's theory of impaction shows the characters of a well-marked fracture, with displacement of the lower fragment, as in the group above referred to, recognisable at a simple glance, and without any penetration or impaction of the upper fragment into the lower. In such cases the lower fragment is displaced backwards, rotated on its own transverse axis backwards, and the whole piece is moved to the radial side with displacement of the radial styloid towards the upper extremity of the radius (Fig. 3). The degree of each of these displacements, more or less present in each specimen, varies. In fractures

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[1] *Clinique chirurgicale*, par L. Voillemier, 1842.

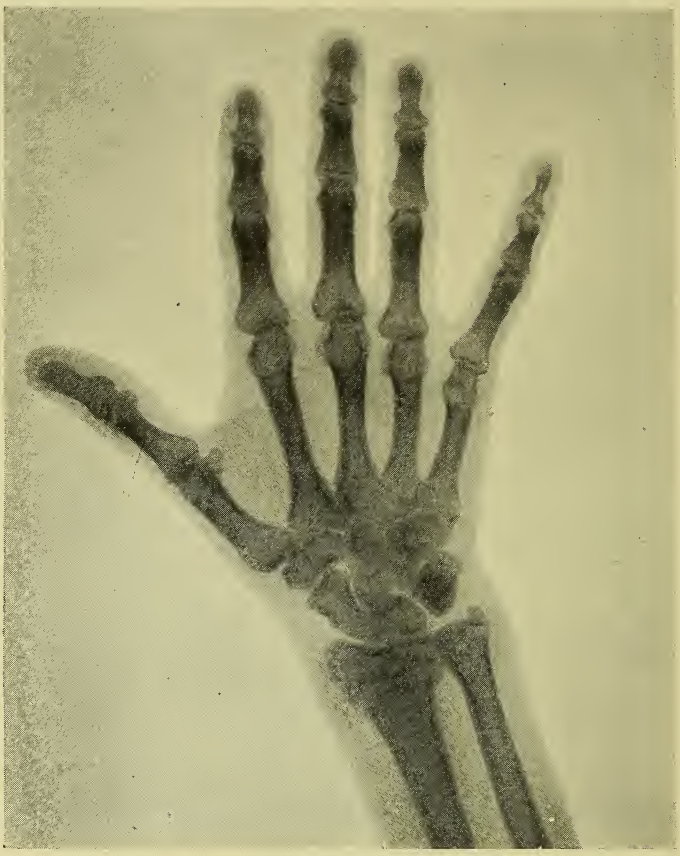

Fig. 2a.

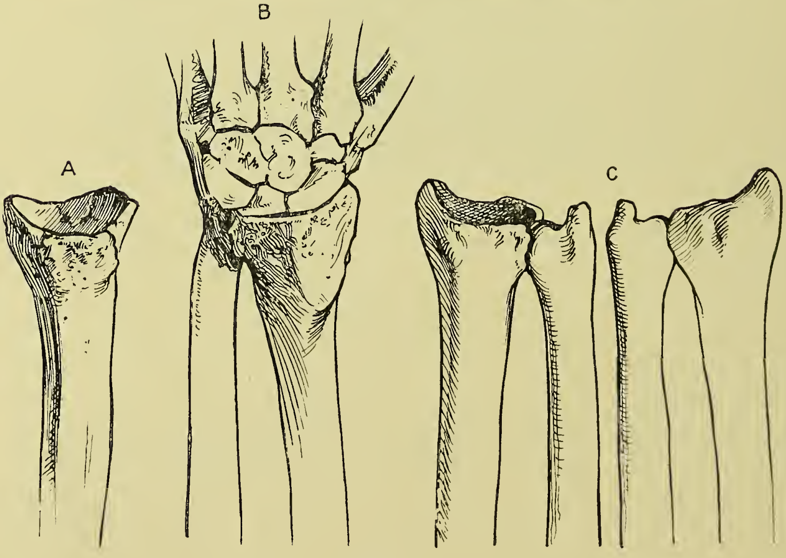

Fig. 3.

caused by great violence, such as a fall from a high building, the backward displacement may predominate, and the lower fragment may clear the upper ; with it the hand and the wrist joint undergo extreme displacement, while the ulna, set free from its connection to the radius and hand alike, becomes dislocated through the integuments towards the inner border of the hand. In other specimens we see the rotation of the lower fragment backwards on its transverse axis, the salient feature of the specimen (Fig. 3 A). In some not very rare specimens the extremely limited development of all three displacements renders the deformity so small that even expert anatomical eyes may fail to appreciate it until close comparison is made with the macerated bone of the opposite side (Fig. 3 C). Such an oversight is made in a well-known osteological text-book,[1] in which an united Colles' fracture, with the minimum deformity, is represented as the normal bone. In such specimens the displacement most constant in its development is that of the radial styloid towards the upper end of the bone. This fact is of great importance clinically, because the altered relation of the radial styloid renders the line drawn from it to the ulnar styloid less oblique than in the uninjured limb, and by the appreciation of this change the diagnosis may be made certain in the living, in cases the description of which I have quoted above from Voillemier's paper, in which the most evident features of deformity are absent.

In discussing the subject of impaction, Voillemier puts in the forefront of his argument the constancy of the three lines of compact tissue seen in the antero-posterior section of united fractures (Fig. 4). He admits four possible modes of impaction : 1. The penetration of both walls of the upper fragment into the tissue of the lower without its being burst asunder ; 2. The same mode of penetration, with crushing of the lower fragment—Dupuytren's fracture *par écrasement ;* 3. The bending or hinging, so to speak, of the anterior walls, with impaction of the upper into the lower fragment posteriorly ; 4. The reciprocal penetration of the fragments, the upper into the lower behind, and the lower into the upper in front. Of these possible forms of impaction he believes the third to be the most common, founding his opinion, apparently, on the observation, "that the impacted line is never double," an observation in which Smith agrees.

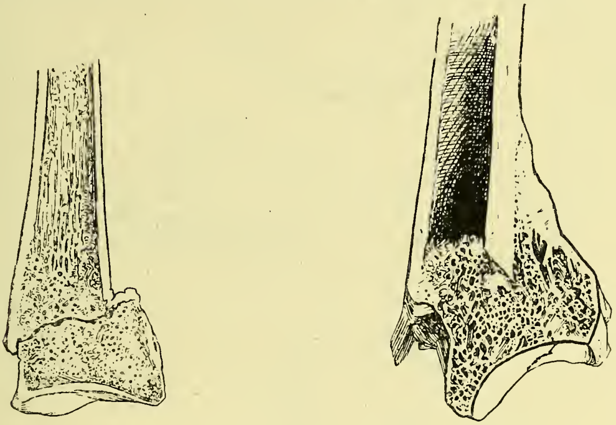

Fig. 4.

I am able to show that exceptions occur to this rule ; further, that comminution is more common than Smith has estimated it to be, and that the paths of the fractures which occur in the lower fragment present a remarkable constancy in position. If I rightly interpret these appearances, the conclusion must be arrived at, that in comminuted fractures reciprocal impaction is the most common form of the accident.

In estimating the frequency of comminution of the lower fragment I apply the following test to the collection before me, which has now reached the number of 120—all Colles' fractures, transverse in the direction of the fractures. Some are recent injuries, a couple experimental, the vast majority old united fractures, in all the lower fragments displaced backwards, with more or less distortion of the carpal surfaces by rotation of the fragments backwards, and the most constant character, elevation of the styloid processes. In estimating the frequency of comminution of the lower fragment I accept as proof the extension of fracture through the articular cartilage of the carpal surfaces. These fractures are, of course, evident in recent specimens taken from patients who have died of other injuries. The traces of the fractures in the carpal surfaces are no less evident in united fractures, for all the world knows that the fractures of articular cartilage remain as permanent marks on the surfaces. Only one change in a few specimens can mask them—the supervention of chronic rheumatic arthritis in the articulation. Applying this test it is certain that I omit specimens which are examples of impaction, but in which the lower fragment has not been split through. In tracing these lines in united specimens a remarkable constancy in their course is appreciable, a constancy which suggests at once a constancy in their cause.

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[1] Holden, *Human Osteology*, 6th ed. p. 56.

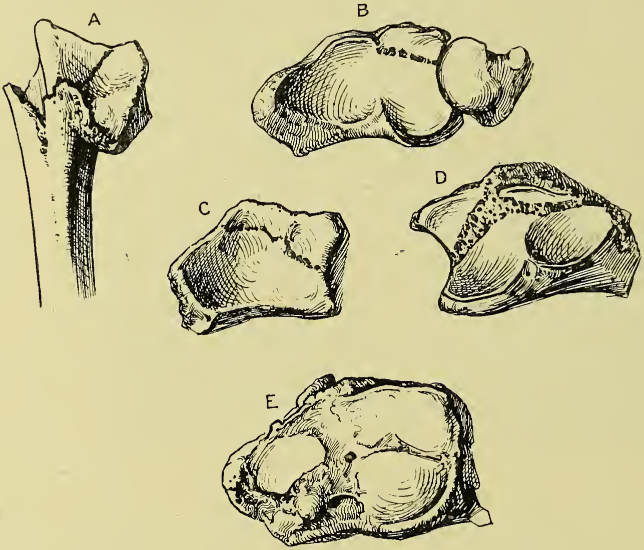

Fig. 5.

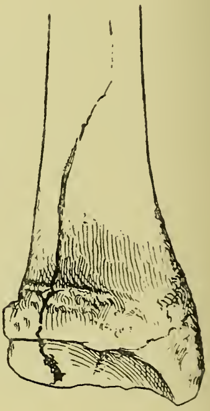

Fig. 6.

In twelve specimens the minimum fracturing of the carpal surface occurs (Fig. 5). A line of fracture passes in these through the articular cartilage of the ulnar facette, and turning into the carpal articular surface passes to its dorsal margin, so the posterior angle of the carpal surface next to the ulnar articular surface was broken off (Fig. 5 A, B). In six specimens the line of fracture, similar to that in the preceding twelve, exists, but there is added to it a line extending along the carpal surface farther outwards in some, forming what has been called Barton's fracture (Fig. 5 C, D). In twenty-two specimens the lines seen in the two preceding groups are present, but they branch forward towards the anterior margin of the carpal surface (Fig. 5 E). In four of the five recent fractures obtained from cases fatal by other injuries, the same pattern of fracturing is seen; these fractures, *par écrasement,* are then only excessive extensions of the impacted fracture. In one specimen these fractures are associated with dislocation of the lower extremity of the ulna.

Of fractures which show no trace of lesion of the carpal articular surface of the radius there are seventy. Some of these, no doubt, presented some degree of impaction, but the majority were free from the complication.

There appears, then, sufficient ground for the assertion that the mode of comminution is constant, and that it results from the impaction of the upper into the lower fragment, taking effect first and chiefly on the side of the fragment next the ulna.

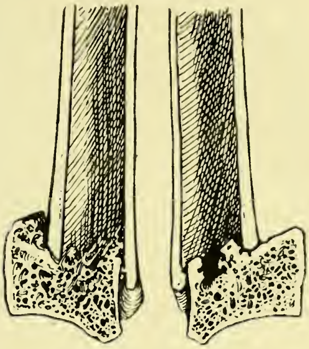

FIG. 7.

A further examination of these specimens shows that, where the fractures remain sufficiently distinct in outline to trace their details exactly, the impaction of the fragments is reciprocal (Fig. 7); that while the posterior surface of the upper pierces the lower, the anterior of the lower penetrates the upper, it may even lead to its splintering. This conclusion is at variance with the opinion of Voillemier; but I believe the explanation of the discrepancy between us is, that hitherto the examination of comminuted specimens has not been made with sufficient care. I believe that in many (Fig. 2) fractures no impaction whatever occurs, and again that in many injuries, Voillemier's third variety, the bending of the anterior wall with posterior impaction occurs. I cannot resist the conclusion to which this collection leads, that in comminuted fractures, which occur in proportion to injuries without secondary fractures of the carpal surface almost in the ratio 5 : 7, the characters are constant and the result of reciprocal impaction of the fragments.

The following appear to be the chief complications of Colles' fracture so far as the specimens preserved in our collection illustrate them :—

1. Necrosis of the lower fragment.
2. Fracture of the shaft of the radius higher up.
3. Fracture of both bones of the fore-arm, also higher up.
4. Fracture of the styloid process of the ulna.

1. The fracture in which necrosis occurred is entirely exceptional; the injury was in all respects of the ordinary type, without excessive deformity or any wound. On the patient, of thirty-five years of age, resuming work at the close of the treatment, which lasted about five weeks, the limb suddenly swelled and abscesses formed, leading finally to amputation.

2. The fractures of the radius alone, higher up, are seen in two instances where the usual distortions of such injuries are absent, or at least very slightly marked; phenomena which I have myself noticed in this complication occurring in the living, the Colles' fracture, so to speak, taking precedence in establishing its deformity, while the fracture of the shaft was discoverable chiefly by its pain and local crepitus.

3. In another specimen, where both bones are broken, the radius very high up, the features of the fracture suggest its having occurred independently of the Colles' fracture.

4. In the instance of fracture of the ulnar styloid the characters of this complication are well seen (Fig. 2). These specimens were more numerous than the collection shows, for I have, in dissecting some now not characteristic specimens, noticed this lesion, but the little fragment of bone is lost in maceration or after the specimens dry. I am confident that in all the fracture occurs as in the examples preserved—a fracture of the styloid caused by traction on the lateral ligament of the wrist, free of direct relation to the attachment of the sacciform ligament; that this fracture unites in the majority by ligament only with very insignificant deformity. I notice these points merely to give expression to the opinion I hold as to this complication, that it is of practical importance only as explaining the occasionally severe pain observed at the position of the ulnar styloid in recent injuries, that it is quite unimportant in regard to the deformity or other leading phenomena of Colles' fracture.

The clinical complication of greatest gravity which I have seen in dealing with Colles' fracture is gangrene of the limb. I have twice seen this accident occur in cases which presented other grave injuries; in one I think over severe efforts to diminish the deformity caused by the fracture precipitated the gangrene. In the other there was no special sign to give warning of the onset of gangrene, only the unusual complaints of pain in the limb on the evening and night of the second day.

The treatment of Colles' fracture should be directed, in the first instance, to the reduction of deformity as completely as it can be effected by the guarded use of traction. One must bear in mind that nearly one-half the cases are impacted fractures, and that it must in consequence be impossible to fully restore the form of the broken bone. The invariable existence of deformities in the examples preserved in our collection, and in every other that I have seen, goes to prove that one never succeeds in a perfect reduction. The reduction is a very painful proceeding for the patient, and I have many times found patients absolutely refuse to allow it to be carried out to the full degree. Many patients, particularly males, become faint when extension is made, and if the surgeon is wise, instead of suspending the reduction because of the patient's fainting, he will at once complete the reduction as far as he fairly can while the fainting lasts. I think if the injury the surgeon is called to treat is quite recent, he should have at his hand two flat wooden splints, well padded, long enough to reach from just below the elbow joint to the tips of the fingers. A pad of wool to be applied to the palmar surface of the fore-arm, thickest beneath the actual seat of fracture, should be placed on the anterior splint. As the reduction is effected the palmar splint is put in position, while extension is kept up by Colles' grip, then the dorsal splint is applied, and the apparatus fixed by a roller turned firmly but without excessive strictness. In a day or two, as soon as the degree of swelling of the soft parts has been estimated, and is seen to be on the decline, a more agreeable support for the limb is made of light poroplastic felt, moulded to the front and back; this can be shortened by cutting away the dorsal and palmar supports of the fingers and thumb, and by reheating, adjusted so as to fit the fore-arm and hand as the swelling subsides. Or instead of this material the limb may be lightly put up in plaster of Paris. Three or four weeks of support to the limb is best, and, as the fingers are freed by shortening of the splints, their motion early comes into play.

Colles' Fracture Reversed.—Of the rare injury, fracture of lower end of the radius, with displacement of the lower fragment forwards, the collection of the School of Physic contains seven specimens, with a cast of an eighth which is in the R. C. S. I. collection; of these, two agree with the description given by Professor Gordon; two, on the other hand, agree with the figure published by Voillemier. The relative number of these specimens proves the inapplicability of the name applied by Professor Gordon to this fracture, "articular," for we see here the fractures as remote from the joint as in ordinary Colles' fractures.

We possess also the original cast published by Professor Smith, and now casts of two cases observed in practice by myself. Of these specimens two may be regarded as conformable with Professor Gordon's articular fracture, being fractures which pass obliquely from the dorsal margin of the carpal surface to the palmar surface of the shaft of the radius, three-quarters of an inch from the end of the bone. Of the remaining five, three were impacted with fractures of the carpal surface, after the manner of ordinary Colles' fracture; two presented no signs of such impaction.

The following is the history of an example of the injury observed by myself:—

A jockey, aged nineteen, was backing for the first time a three-year-old filly, she bucked and burst the girths, and sent saddle and rider into the air. The rider fell to the ground, striking first on the back of his right hand. I saw him the day following. The injury had been readily recognised by the deformity, the facility of reduction, and the distinct osseous crepitus felt on the reduction ; immediately on the relaxation of the reducing force the deformity recurred. I took the patient into hospital and verified the details, and treated the patient until union was obtained.

It would seem, then, that Rhea Barton, and Mr. Callender, and Professor Smith were hitherto the only observers of the clinical details of the injury, and that the pathological facts bearing on it were not much more plentiful here or in America. I need not then apologise when I record the recent injury taken previous to reduction, and a series of eight pathological specimens obtained, one from the museum of the Royal College of Surgeons, to which it was presented by Mr. Swan in 1885, and the seven which I have myself procured from the anatomical department of the School of Physic in Ireland. I think we may then fairly reject the conclusion arrived at by M. Lecomte, who states his opinions in a series of dogmatic assertions, of which this is the first :—" All the fractures of the inferior extremity of the radius are produced by a single and the same class of fall—falls on the palm of the hand."

It is, I think, clear that the reversed Colles' is the result of a fall on the back of the hand.

Epiphysary Separations.—The next group of our series includes two specimens of epiphysary separation, with which I have also the casts of the limbs of the patient. The third specimen I place in this group with less confidence, but I will presently state my reason.

The two recent specimens are taken from the limbs of a boy who died a few days after a fall from a height on his head, the head injury proving fatal.

The casts in these cases (Fig. 8, A) contrast, as many similar casts in our collection do, with the representations of the deformity (Fig. 8, B) in Colles' fracture, in the transverse features of their dorsal and palmar projections, and in the folding of the skin in the palmar depression, and again in the absence of abduction of the hand. If we add to these the easy reduction of the fracture and the facility of obtaining crepitus, and, still more remarkable, the facility of maintaining the reduced fracture in place, phenomena all long since pointed out by Smith, which I may state I have frequently observed and verified myself, there are, I think, ample grounds for questioning the recent statement of Professor Macleod, that "there are no distinctive signs by which a separation of it (the radial epiphysis) can be differentiated from an ordinary Colles' fracture." The united fracture I place in this group is remarkable when compared with all or any specimen of the collection of Colles' fractures, for, while there has been clearly a fracture at the usual seat, it alone presents the feature of a styloid process bearing its normal relation to the ulnar styloid, and a carpal surface almost without maldirection. There are faint traces of an ulnar fracture just above its epiphysis, as often occurs with the radial detachment. The recent specimens, I should note, present fractures confined to the radius. On one side the lower fragment is comminuted ; on the opposite, simple ; a little scale of bone is detached from the diaphysis on the side which shows the comminution.

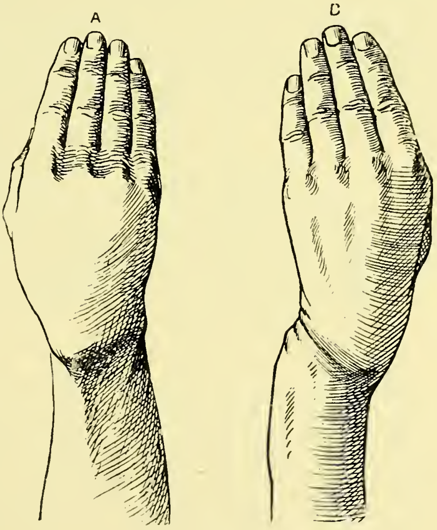

FIG. 8.

Longitudinal Fractures of the Lower End of the Radius.—I shall now briefly examine the longitudinal fractures of the lower end of the radius, and I hope show that they result from causes other than falls on the palm of the hand. The leading case which bears on this question is that recorded by Bigelow.

The catalogue of the Warren Museum contains this description of the specimen, 1035 :—" The lower extremity of the radius, showing a stellate crack of the articular surface and extending upwards for more than an inch. From a patient, who died of other injuries. At first there was only a complaint of lameness as from a sprain, but after some days there were swelling and tenderness which, from their persistence, led Dr. B. to diagnosticate a stellate crack of the bone as a probable result of the fall, and of which he had met with a similar case two years previously. Dr. B. remarked that the bones of the wrist would act as a wedge upon the concave articular surface of the radius, and that this case would explain the persistence of some cases of sprained wrist." Case published in the *Medical Journal* (vol. lviii. p. 99), with a figure, and copied with the figure in Dr. F. H. Hamilton's work on *Fractures*, 1848.

The details of the injury given here are very meagre, and leave us in doubt as to whether the patient fell on the palm of the hand or not. From the description and figure it appears that there was not any transverse fracture of the lower end as in Colles' fracture, and that the fissures were not, therefore, such as occur in the articular surface in nearly one-half of the cases of Colles' fracture.

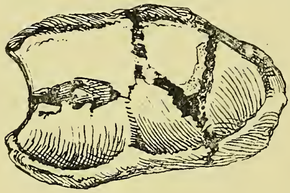
Fig. 9.

A series of radii which belong, one to the museum of the Royal College of Surgeons, and five to the museum of the School of Physic, present fissures that occurred during the lives of their owners. The earlier specimens that I obtained showed fissures of the articular surface only, and occupied my attention because of the difficulty in explaining their origin. This specimen (Fig. 9), placed in the museum of the college by the late Dr. Richardson, was the first which I saw that helped me to a solution of the question ; it was damaged by the hand and forearm being caught in machinery, probably a cog-wheel ; such is the note on the label.

I at once tried if I could produce such fractures on the dead bone. If one wraps a towel round the end of the dry bone, and presses with the heel on the carpal end of the radius as it lies on the ground, the bone yields and crepitus is felt ; with the lighter degrees of pressure it is possible to break the bone only in the concave surface of the articulation, and to produce lines identical with those of these macerated specimens, strictly limited to the articular surface (Fig. 10, A, B, C). A greater degree of force extends the fissures upwards in the compact wall of the bone. If a man be trampled in a crowd, or if a weight of any kind falls on the wrist, such a damage can readily happen, still more if a wrist, as we often see, be rolled in machinery. It seems more rational to look for the cause of these fissures in such injuries than to attribute them to the wedge action of the carpal bones.

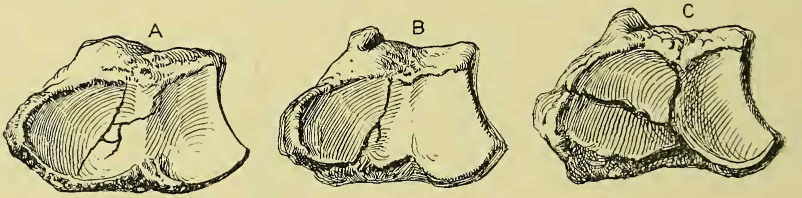

Fig. 10.

The experiment I have described is best made on bones in which maceration has removed the articular cartilage ; in these the fissures of least degree will be seen in the articular layer of bone, but would be concealed in the bone covered by cartilage. This is illustrated by one of my specimens, where the cracks are evident in the shaft on both palmar and dorsal sides of the bone, and are traceable into the cartilage at each margin of the joint, but have not torn it.

Fracture of the Radial Styloid.—Of the fracture of the radial styloid I can only say that this specimen (Fig. 11) is a perfect example, remarkable for the downward displacement of the fragment, which has caused elongation of the outer border of the bone, probably as we see the inner malleolus displaced by traction of the internal lateral ligament of the ankle joint. I have never recognised the injury in the living, and this united fracture is the only example I have seen.

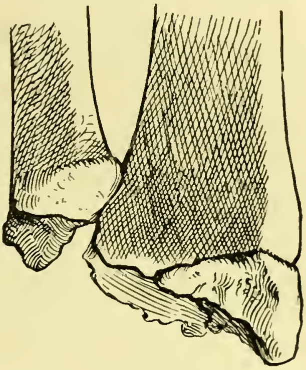

Fig. 11.

Fracture of the ulnar styloid occurs in a considerable number of cases of ordinary Colles' fracture in consequence of the strain communicated to it by the internal lateral ligament of the wrist. It is not unusual to find the fracture in the X-ray photographs of the injury.

The interest of the injury is derived from the fact that pain in position of the fractured process is so constant an attendant on the ordinary fracture.

Fractures of the Carpal Bones.—Simple fractures of the carpal bones are of very rare occurrence, but as the use of the Röntgen rays becomes more general their great rarity will probably disappear. The scaphoid is the bone most often broken. Next to this is the semilunar, but were it of any practical advantage a complete list might be made out. Direct blows may produce any of these fractures. The cause, as far as I know, which breaks the scaphoid is over-extension of the wrist, as in the following example:—A man of middle age and full strength was lowering a cask of pork into a cellar, letting it down a sloping plank. The cask proved too heavy for his hands pressed against it, and fell in spite of his resistance. At once he felt sharp pain in his wrist and noticed a projection at the back of the joint. He was presented to me next day in the accident room of Sir Patrick Dun's Hospital. I concluded that the tumour was either part of the scaphoid broken off and displaced, or there was partial dislocation of the bone unbroken. The small size of the tumour suggested that the case was one of fracture. I reduced the projection with a little manipulation, and when reduced there did not appear to be any tendency to recurrence of the projection. I did not get crepitus in any part of the manipulation.

I put a compress over the dorsal aspect of the wrist, and the next day had a skiagraph taken which shows the fracture very distinctly. I have never since seen the patient, so that I conclude he is free from trouble.

I have placed in our collection a fragment, nearly one-half of the scaphoid, which was given to me by my friend Dr. H. Fitzgibbon. He obtained it in this way: A man had had his hand and wrist jammed in the cogs of a machine. The contusions behaved kindly for a time, but on the man's attempting to use the limb a swelling appeared at the anterior aspect of the wrist, which presently suppurated, and on the abscess being opened the detached and necrosed fragment of the scaphoid presented in the wound and was removed. In falls from a trapeze, in which the individual comes to the ground on his knees and over-extended wrists, the scaphoid may be broken. Of this injury I have representations of the Röntgen rays in two cases. Our collection contains a single example of the semilunar bone broken in several places without any lesion of the other bones either of carpus or fore-arm. One specimen of fractured cuneiform bone exists in Dublin; the cuneiform which corresponds to the radius represented in Fig. 9: a cog-wheel injury.

I know of a single example of fracture of the pisiform bone (Stimson, 2nd edition, page 666).

It would appear from the facts recorded with regard to the fractures of the bones of the first row of the carpus that union does not readily take place in this injury. As yet I know no example of osseous union having been observed.

Wrist-Joint Diseases.

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TUBERCULOSIS.—The wrist joint holds a position midway between the shoulder and the elbow as regards its liability to tuberculosis. The disease in the elbow accounts for about 7 per cent of all joint tuberculoses, that in the wrist for 5 per cent, and that in the shoulder for 1½ per cent. This fact of its *comparative* rarity, coupled with the very insidious onset which characterises the disease in this joint, often leads to a delay in recognition of the condition and consequent serious permanent damage to the joint.

Two features are worthy of remark in this disease. Of all joint tuberculoses that of the wrist is perhaps the one most specially liable to be associated with phthisis. And the second point is that, though it occurs in children, it is essentially a disease of adult life; many patients suffering from it are no longer young, and some of them are old. I amputated the hand in a severe case in which the patient must have been between sixty and seventy years of age.

Symptoms.—Swelling is an early symptom. It is more marked on the dorsal surface, but even on the palmar surface comparison with the other wrist shows that the normal hollows are filled up; there is "a fulness and smoothness of outline, both on the palmar and dorsal aspects, which, even when it is slight, is very characteristic." When the disease has existed for some time the carpus may be found displaced somewhat forwards; the wrist slightly flexed, or the fore-arm, hand, or fingers in a straight line; the thumb applied to the hand, and the fingers held close together, though in some cases they may be widely separated. Atrophy of the muscles of the fore-arm is usually found early and well marked. With the flat fore-arm, the bulging, thick wrist, and the thin, tapering, glistening fingers stuck together, the disease presents a notable and unmistakable picture. Flexion and extension may seem at first sight to be unrestricted in an early case, but even at the beginning of the disease the limits of these movements will be found on careful examination to be narrowed. The same may be said of pronation and suppuration, and of course later in the disease only slight movements are possible. Pain is often absent for a considerable time, but in the later stages may be extreme. Tenderness will be found early over the posterior and outer aspect; while grasping the fingers and fore-arm, and pressing the bones of the wrist together—care being taken neither to flex nor extend the joint—may elicit pain and indicate a correct diagnosis at an early stage of the disease. Grasping each finger in turn, too, and pressing it and its metacarpal upwards, so as to "crowd" the corresponding carpal bones, may give some indication of the position of the diseased areas.

Lateral mobility is a very important symptom. It is due to softening of the ligaments by the disease, and is quite an early symptom. It is made evident by grasping the fore-arm and the hand while they are in a straight line, and moving the hand laterally. The symptom is virtually pathognomonic of carpal tuberculosis.

As the disease progresses the joint becomes so insecure that the patient supports the fingers with the other hand. Abscesses may form, the resulting sinuses opening more frequently on the dorsal than on the palmar surface.

Cause and Pathological Anatomy (*see* JOINTS.)—Invasion by the tubercle bacillus is often determined by some minor trauma, such as a sprain or over-exertion. Owing to the number and small size of the bones in the joint it is difficult to decide whether the disease commences more frequently in the bone or synovial membrane, but probably most cases are primarily synovial. Tillmanns holds the opposite view. Primary osseous deposits are found in the end of the radius, and occasionally in the second and third metacarpal bones. Sometimes the joint is invaded from a tubercular teno-synovitis of the neighbouring tendons. The ligaments are early invaded and softened.

Diagnosis.—The disease is to be distinguished from tubercular teno-synovitis and from arthritis deformans. In teno-synovitis there is indeed a chronic bossy swelling, but pain is conspicuous by its absence, and the movements of the wrist and of the fingers continue entirely, or almost entirely free. In arthritis deformans the atrophy of the fore-arm is not comparable with that in tuberculosis, and later all mobility is absent.

Treatment.—The means of treatment at our disposal are immobilisation by a splint, Bier's congestive bandage, iodoform injections, and operative procedures.

(*a*) *Immobilisation by a Splint.*—In this connection three things must be remembered:—Firstly, that stiffness in the fingers is apt to be produced by adhesions forming round the tendons passing over the joint. Secondly, that in a normal hand the grasp of the fingers is weakened if they and the wrist are in the same line with the fore-arm,—to get the full power the wrist must be partly extended; therefore a wrist anchylosed in a straight line or in flexion will have the use of the fingers impaired, even though the tendons may be quite free. Thirdly, the thumb must not be allowed to become stiff, applied to the hand, where it will be useless, but must be free to drop. Lister's well-known splint is the best for the purpose. It reaches from the elbow to the heads of the metacarpals, has a pillow of cork fixed at the lower end, and is of a breadth only to support the metacarpals of the fingers. It is applied to the palmar surface, the cork pillow bends back the wrist while the fingers are left free for movement. The thumb drops over the side of the splint, which should be provided with a small support on its under surface, so that the thumb may hang free when the arm is laid down, as *e.g.* during the night. To prevent it slipping round this splint should have a vertical piece of wood on one or both sides near the elbow. Rest maintained in this way may alone suffice to produce an absolute cure; but the splint must be worn for months.

(*b*) *Bier's Congestive Bandage.*—If improvement is not marked under treatment by a splint, the congestive bandage and injection of iodoform may be added. If needful the fingers and hand may be bandaged in the ordinary way, the wrist is left uncovered, and immediately above it the fore-arm is bandaged tightly with elastic webbing applied over a protecting layer of lint, so as to produce considerable venous congestion. The fingers should be watched to ascertain that the bandage is not too tight. It may be taken off for six hours each day, or may be left on continuously for weeks. I have seen remarkably good results following this treatment in disease of the wrist and ankle. The splint may be used at the same time.

(*c*) *Injection of Iodoform.*—After the congestive bandage has been used for some four weeks it may be discontinued and injection of iodoform begun. As the carpal bones are usually much softened they can be penetrated without difficulty. A strong, narrow syringe filled with a 10 per cent emulsion of iodoform in glycerine should be entered on the ulnar side below the styloid process, pushed across to the radial side, and then gradually withdrawn while the injection is made. The injection is thus parenchymatous as well as intra-articular (Senn). When the injections are repeated every ten days to three weeks, they may be made on the dorsal aspect at suitable points; Bier's bandage may be reapplied a day or two after the injection. This treatment has been very successful.

(*d*) *Operative Procedure.*—It should be distinctly understood that tuberculosis of the wrist joint is peculiarly amenable to treatment by immobilisation, and that the surgeon who is dealing with an early case may confidently look for gratifying results from the patient use of a splint alone, or that aided by the congestive bandage and injection of iodoform. Few cases, then, should require operation.

Incision.—There is no doubt that simple incision and drainage will succeed in arresting the disease in cases which have resisted "expectant" treatment. The incisions should be made so as to avoid injury to tendons, vessels, and nerves, and the wounds should be kept open by gauze packing or drainage tubes. They should be made over the most swollen, softened, or tender parts.

Arthrotomy and Curetting.—This should be tried before formal excision is resorted to, for reasons which will be found in the following paragraph. Incisions should be made over diseased areas—usually on the dorsum—or sinuses should be opened up, and all tubercular bone and synovial tissue removed by Volkmann's spoon and scissors. Iodoform should be dusted in, the spaces packed with gauze, and a Lister splint applied. Assiduous pursuit of the disease in this way will usually be rewarded by results which will far surpass those that follow excision.

Excision of the Wrist.—A review of the statistics of this operation will convince any impartial critic that the results which follow it are distinctly disappointing. The mortality, of course, is "insignificant," but the functional results are poor, and this, of course, has to be considered in deciding for excision as against amputation. I do not deny that isolated cases occur in which the surgeon has the gratification of observing an almost perfect use of the hand as the result of excision, but such cases are the exception. Often the hand can do no more than merely hold articles, and these light ones. Possibly this is often due to a formal resection of the joint being too long delayed.

The best method is that by a *single incision on the ulnar side* (Heron Watson). It is very efficient, as access to the parts is free, and it is much easier of performance than Lister's or other methods. An incision about three inches long is made down to the bone on the ulnar side of the forearm towards the palmar aspect, over the lower end of the ulna, the wrist, and part of the fifth metacarpal bone. After the lower end of the ulna has been cleared, fully an inch of it is removed. The way is opened at once for easy and thorough removal of the disease. As each bone of the carpus is met, the tendon can be easily separated from its surfaces without damage; the carpus is removed piece by piece, the trapezium being left if sound. The bases of the metacarpal bones are removed, being turned out of the wound if needful. The metacarpals towards the ulnar side may be dealt with before the radial side of the carpus is attacked; in this way each successive step is made easy. The end of the radius is removed with bone forceps. Few vessels require ligature. The wound is partially stitched and drained by a tube, or it may be packed with gauze. The fore-arm and hand are bandaged to a Lister splint. Early passive movement of the fingers must be attended to.

Amputation.—Excision should not be performed in cases in which the patient is old or in weak health, or is the subject of well-marked phthisis; nor in which the disease is too widespread to admit of complete removal, or has involved the tendon sheaths in tuberculosis with suppuration and sinuses. In such cases amputation is the proper practice; it should be performed by the modified circular method, or any other that is suitable, as close above the wrist as possible.

PYOGENIC DISEASES.—These result either (1) from infection through the blood stream, as in (*a*) osteomyelitis of the radius and ulna, or possibly the metacarpal bones; or (*b*) in pyæmia: or else (2) from without, as in the direct infection of wounds, operation or accidental, or from the spread of the organismal inflammation from a septic teno-synovitis of the tendons of the wrist.

Suppurative arthritis from osteomyelitis of the neighbouring bones is not nearly so common in the wrist as in other joints, as the knee and ankle (see JOINTS); but *pyæmic suppurative arthritis* quite commonly occurs in the wrist in cases of pyæmia. The joint swells often without giving the patient much pain, the skin may not be inflamed, and indeed the surgeon may notice the condition only when taking the patient's hand to examine the pulse. *Treatment.*—The joint should be incised and drained, and the limb bandaged to a splint with the hand in dorsiflexion. Wonderfully good movement may be retained by the joint, especially if the tendon sheaths have not been involved.

Septic arthritis following suppurative teno-synovitis is unfortunately not a rare sequel to a neglected or inefficiently treated "suppurating whitlow." The *symptoms* will depend on the type of the original inflammation and its organism. But once the joint is affected the severity of the symptoms is increased; the pain becomes very severe, the swelling and œdema of the wrist and hand increase, and the skin is reddened. The constitutional symptoms correspond. If untreated the joint will soon be disorganised; in a few days lateral movement will show that the ligaments are softened, the slightest movement causes intense pain, and the bones, denuded of their cartilage, can be felt to grate on one another. The sheaths of the flexor tendons, of course, are the usual source of the disease. *Treatment.*—As soon as the invasion of the joint is recognised it should be freely opened, the site of the incisions being determined partly by the spots of greatest tenderness, and partly by considerations of access and drainage; then the joint can be readily opened up and drained on the inner side just below the styloid process of the ulna. If possible there should be continuous irrigation with a weak antiseptic, while the limb is placed in a splint with the wrist dorsiflexed. In a severe case little movement may be ultimately expected. *Infection of the joint from wounds*, operation or accidental, is followed by similar symptoms, and demands the same treatment.

GONORRHŒAL ARTHRITIS (*see* JOINTS).—This disease does not occur so frequently in the wrist as in the knee or ankle, but the possibility of its occurrence should be borne in mind lest it be mistaken for rheumatic arthritis, acute or chronic. Since it very seldom in any joint results in suppuration, it should be considered apart from pyogenic affections. Since some stiffness may result, it is most important that the hand should be dorsiflexed in the splint already described.

CHRONIC "EMPLOYMENT" ARTHRITIS.—Madelung has described this condition, which, though not rare, is at the same time apt to be overlooked, at least in its earlier stages, when treatment is of more avail than later. It is a form of chronic inflammation met with mostly in young people, and especially in those whose wrists are subjected to violent or excessive movements—washerwomen, workers in certain trades, boxers, tennis and cricket players. Sometimes it occurs as a change at the radio-ulnar joint, where the ulna, apparently from relaxation of ligaments, projects prominently backwards, and the carpus is displaced forwards. In others the firmness of the radio-carpal joint does not seem to be impaired, but there is a disturbance of growth. The articular surface of the radius is altered so that, apparently in consequence of violent movements mostly in the direction of flexion, growth is arrested on the palmar aspect, and the dorsal edge overhangs; the carpal surface of the radius becomes oblique, and the carpus is subluxated forwards and cannot be replaced in its normal position. Slight pain, at first complained of, afterwards ceases, some disability alone remaining. *Treatment.*—The excessive movement must not be given up, and a leather "bracelet" should be worn for months.

ARTHRITIS DEFORMANS (*see* JOINTS).—The wrist is not infrequently the seat of this disease, which bears an importance to the surgeon on account of the similarity between some of its features and those of tuberculosis. In both there is a chronic disease with pain, swelling, and stiffness of the joints. Hence it is well to remember in this connection two features highly characteristic of tubercular disease of the wrist. They are marked atrophy of the fore-arm and early lateral mobility of the joint.

CHARCOT'S DISEASE (*see* JOINTS.)—The wrist is but rarely affected with this disease. As it sometimes appears in locomotor ataxy before the tabetic symptoms, there is need for care to avoid an error in diagnosis. Were it to be a case of the mild type, or were the disease, beginning with milder symptoms, to pass into the severe form with swelling, grating of the bones, and marked lateral mobility, the disease—especially with this last symptom—might be mistaken for tuberculosis were it not for one symptom. The remarkable absence of pain and tenderness, so extraordinary a feature of Charcot's disease, ought to make a mistake impossible.

TUBERCULAR TENO-SYNOVITIS (*tubercular tendo-vaginitis,* "compound ganglion").—This is a local tuberculosis which affects the synovial sheaths of the tendons both on the flexor and extensor surfaces of the wrist. Though undoubtedly infrequent in comparison with joint tuberculosis, tubercular tendo-vaginitis cannot be called rare in this region.

Symptoms.—The first symptom to be noticed is usually a *swelling* on the back or front of the wrist. It is a more sharply defined one than the swelling occurring in tuberculosis of the joint, is often oblong with rounded ends, running parallel with the tendons. Sometimes the swelling is fairly round, but it often consists of "compartments," lateral offshoots spreading from the central mass; hence the name "compound ganglion." If it occur on the front of the wrist it may be "hour-glass" in shape, the annular ligament causing a constriction between a mass in the palm and one over the upper part of the wrist. The swelling may be movable transversely with the tendons, but not longitudinally. According as it is of the fungus or hydrops variety, it will feel semi-elastic or fluctuating, and in the latter case especially the presence of "rice-bodies" may impart a characteristic sensation as they are pressed from one part to another of the swelling. *Pain* is by no means a marked symptom; in fact, it is often absent for a long time after the swelling has attained a large size. *Movement* of the fingers similarly may for long be quite free, though as the disease progresses it may destroy the tendons and impair the use of the fingers. Eventually the wrist joint may be invaded, or abscesses may form and open spontaneously with disastrous results from the consequent sepsis.

Pathological Anatomy.—Two forms of this disease are usually described: (*a*) The tendon sheaths are distended with synovial fluid, their walls are not greatly thickened with granulations, but they are frequently hung with numerous hard white masses, the *corpora oryzoidea*, or "rice-bodies" ("melon seeds"). These vary in size up to that of a pea, are flattened and ovoid; some hang loosely packed from the wall of the sheath, while others float free in the fluid. Though tubercle bacilli are rarely found in them, they produce tuberculosis in animals inoculated with them. (*b*) In the second variety the swelling is due mainly to massive fungous granulations which enormously increase the thickness of the sheaths, there is little fluid, and rice-bodies are wanting. As a matter of fact these forms may be found combined. The tendon itself is eventually invaded; as one dissects the thickened sheath off in the operation for the condition, the tendon is sometimes found to be so slender as to require care not to rupture it; while in some cases the glistening white fibres will be followed up till at last they are lost in the tubercular mass, there is an actual gap in the continuity of the tendon. After the condition has been apparently cured by excision of the sheath, it may recur in adjacent sheaths, and eventually invade the joint itself. I excised the sheaths and a huge swelling the size of an orange from the common extensor tendons of the wrist in a young man who made no complaint except of the swelling; two years later it recurred in the extensors of the thumb, and was again successfully removed; after another interval of two years the disease attacked the wrist joint, but was eventually successfully combated by the congestive bandage and iodoform injections.

Diagnosis.—The "compound ganglion"—a term which should be entirely abandoned for "tubercular teno-synovitis"—ought usually to be easily distinguished from the simple ganglion. The following are the points of distinction. The ganglion usually appears as one single round tumour, without accessory compartments as in the tubercular disease; should the ganglion be "compound" in shape, however (which is seldom the case), its tenseness and firmness, especially when the wrist is extended, serve to distinguish it from the much softer fluctuation or else more boggy feeling of the other; and, lastly, if required, the diagnosis may be absolutely confirmed by a puncture which evacuates in the case of a ganglion the characteristic fluid resembling soft glycerine jelly, while unmistakable synovial fluid or even minute rice-bodies will escape from the tubercular swelling.

Treatment.—It may be that the congestive bandage and iodoform injections will prove as efficacious in the form of tuberculosis as they prove in joint tuberculosis, but as yet no treatment has been followed by results that can compare with *excision of the affected sheaths*. The operation is always an extensive and prolonged one. An incision should be made longitudinally over the swelling and considerably beyond it at each end, or else a flap with its convexity to one side should be raised so as fully to expose the diseased area. After separating the tumour from the healthy tissues by blunt dissection, the operator splits the sheath longitudinally for the entire length of the disease, and then with fine scissors or the knife dissects it away and cuts it off from the healthy tissue at each end. If a gap be found in a tendon the two ruptured ends may sometimes be sutured in the ordinary way by the splitting method. The wound is then closed, with or without a small drain, as is thought advisable. The splint, which is required for the first ten days, should at the end of that period be discarded; passive movements are begun, and the patient is encouraged to move his fingers. Perfectly free movement is to be looked for.

PYOGENIC TENO-SYNOVITIS.—By far the commonest cause of this condition in the tendon of the wrist is "whitlow," septic infection of a wound of a finger, though it may follow a wound of a tendon sheath. The violent inflammation which ensues is very apt to produce necrosis of the tendon, or, if the disease stop short of that, firm adhesions may form which render the corresponding fingers useless. The disease as it occurs in the fingers has already been described (see "Hand"). The *symptoms* here are of the same character; the palmar tendons are, of course, much more frequently affected. *Treatment.*—As soon as the presence of pus in the sheaths is suspected they should be laid freely open. The sites for incision should correspond to the tender areas, and the highest point invaded by pus at or above the wrist can be determined with precision by noting the highest spot of acute tenderness on pressure. The wound should be washed out with sublimate lotion and drained by tubes. Whenever the wounds begin to heal, voluntary and passive movements of wrist and fingers should be commenced at once, and be so assiduously persevered with that all stiffness which can possibly be avoided may be prevented.

ACUTE TENO-SYNOVITIS (*non-pyogenic*).—This disease may be considered as occurring in three forms: (*a*) Dry crepitating teno-synovitis; (*b*) Dry plastic teno-synovitis; and (*c*) Acute serous teno-synovitis (Watson Cheyne).

(*a*) *Dry crepitating teno-synovitis* is apt to occur as an acute disease after prolonged and excessive use of the hand and fingers, in the work of washerwomen, pianists, and others; in these it occurs mostly on the extensor aspect. The *symptoms* are subacute pain on pressure and on movement, slight stiffness, and occasionally slight swelling; in addition, when the tendons move a characteristic sensation of friction is produced (as "when two pieces of silk are rubbed one over the other") palpable both by the patient and surgeon. Spontaneous cure is the rule, but relapse is common. *Treatment.*—The hand should be placed on a Lister splint for a week, and if this does not suffice, a blister will be found in this affection specially useful; as it heals, the moderate compression produced by a firm bandage over wool will aid the cure.

(*b*) *Dry Plastic Teno-Synovitis.*—This is the much more serious variety which results in adhesions, following Colles' fracture, suppurative teno-synovitis, and similar conditions, though it may arise in rare cases without a trauma, when, of course, it is *called* gouty or rheumatic. Apparently it may exist without actual invasion of the sheaths by infective organisms. Acute pain and great stiffness of the fingers are the chief *symptoms;* in the first few days of the disease soft adhesions may be felt to break down on movement of the fingers. The adhesions, if left to themselves, will eventually become so firm as to render the fingers useless. The *treatment* consists in resting the hand in a sling for a week and applying hot fomentations in the acute stage; after that has passed, at the end of the week, passive movements and massage should be begun *and should be continued* till patience and perseverance are at length rewarded. If the surgeon should encounter the condition at a later stage than the first, repeated attempts must be made to break down adhesions under nitrous oxide anæsthesia, with massage and movements in the intervals.

(*c*) *Acute Serous Teno-Synovitis* (See "JOINTS, GONORRHŒAL ARTHRITIS").

CHRONIC TENO-SYNOVITIS occurs in two forms, usually in the palmar sheath:—

(*a*) *Simple Chronic Teno-Synovitis.*—The only *symptom* in this form is a painless, slowly growing swelling, which hardly interferes at all with movement of the wrist or fingers. In the palm it sometimes extends above and below the annular ligament, under which the fluid can be pressed from one compartment to the other. The wall of the sheath is not appreciably thickened; it contains a clear pale yellow fluid. *Treatment.*—The swelling should be incised above the annular ligament, and a drainage tube inserted and kept in as long as needful; passive movements should be begun gently after a week.

(*b*) *Villous Teno-Synovitis.*—This is an affection which might be mistaken for tubercular teno-synovitis, but is a distinct disease, resembling arthritis deformans in joints. The tendon sheath is markedly thickened and lined with villous projections, and is distended with fluid. The *symptoms* in this form are the presence of a swelling which fluctuates, and at the same time gives the sensation produced by the outgrowths; the free fluctuation and absence of tubercular symptoms will help to distinguish it from tuberculosis. *Treatment.*—A somewhat severe operation is required, at least if the sac extend above and below the annular ligament. The ligament must be divided, and the whole sac dissected out; the ligament is then sutured and the wound drained. Rest and passive movements are combined in the later stages as before.

TUBERCULAR OSTEOMYELITIS OF THE METACARPAL BONES.—This is a chronic tubercular osteomyelitis which frequently affects the metacarpal bones of children, and still more commonly the phalanges of the fingers (tubercular dactylitis). The disease attacks the medulla, producing the usual tissue of tuberculosis, while the compact shell is gradually eaten away from within; at the same time the periosteum deposits new bone on the surface, with the result that the tube of bone has the appearance of having been expanded from within. When the subperiosteal deposit is slight, or is wanting, the shell becomes as thin as parchment, and eventually gives way, leading to abscess and sinus formation. *Symptoms.*—The patient is usually a weakly child, and for long the only symptom noted is a gradually increasing swelling, seen best on the dorsal surface of the hand; the fusiform or "bottle-shaped" character of the swelling is not, of course, so evident in a metacarpal bone as in a phalanx. Little pain or tenderness is complained of till the superficial parts become inflamed, when, in addition, the swelling will increase rapidly, the skin will redden and break down, and a sinus will form leading to the centre of the bone. *Treatment.*—Treated at an early stage cases of this disease may be absolutely cured. The congestive bandage and a splint should first be tried. If these fail, iodoform emulsion should be injected into the bone. These cases are admirably suited for this, as the bone can be easily pierced by the injecting syringe and the whole cavity filled with the emulsion. If the disease has progressed too far to be arrested by these means the bone should not be excised; the swelling should be incised for its whole length, the cavity of the bone thoroughly scraped, swabbed, if needful, with undiluted carbolic acid, and packed with gauze. The usual constitutional means for combating tuberculosis are peculiarly successful too.

Writer's Cramp. *See* SPASM.

Wry-Neck or Torticollis.

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THE term torticollis (*torqueo, tortum,* twist; *collum,* neck) is applied to any vicious position of the head of a more or less persistent nature, whatever its cause.

It is usual to state that the condition occurs in two forms, the congenital and the acquired, though, personally, I have never seen an instance of the former. That is to say, I have never met with a case of wry-neck in which it was affirmed that *as soon as the infant made its entrance into the world the medical attendant noted that its head and neck were permanently twisted.* It is quite possible, however, that if a fœtus were tightly packed in the uterus with an insufficient amount of liquor amnii, and with its head rigidly bent over to one side, it might offer an example of congenital wry-neck. Such cases must be, at any rate, of very rare occurrence. But it is not at all an uncommon thing for a nurse or a parent to call the doctor's attention to the fact, when the infant is two or three days old, that it holds its head towards one shoulder. And a year or two afterwards, if an operating surgeon were closely questioning the mother as to when the deformity was first noticed, it is quite likely that the mother would affirm that it was discovered "directly after birth," and the temptation to call it congenital might, in the circumstances, be almost irresistible.

One frequently sees an infant a few days old persistently bending its head down to one shoulder, turning the face towards the other side, and showing by flinching or crying when the root of the neck is fingered that there is much tenderness there. The meaning of all this is that a sudden and violent movement of the head, as the child was being born, caused the sterno-mastoid muscle to be torn across; blood was poured out into the muscle-sheath; the neighbouring nerves were pressed upon, and the infant could not bear the part being fingered.

In some cases the muscle tears across as the result of the medical attendant or midwife pulling upon the feet, but it may be met with in infants whose entrance into the world has been so easy that neither nurse nor midwife was called upon to help. In a considerable proportion of the cases the children have entered the world breech first; possibly there is a greater strain put upon the muscles in these circumstances. In fat-necked infants the tumour may pass unnoticed for days or weeks, but, as the neck grows, the lump can scarcely fail to attract the attention of the mother.

The sequence of events is probably as follows:—The muscle is torn across by sudden strain, and a considerable effusion of blood and a local myositis ensue; interstitial granulation tissue is formed, and this is shortly converted into fibrous tissue, which, undergoing contraction, produces a permanent cicatricial contraction in the muscle.

Time after time one learns on inquiry that the child with wry-neck had in its early infancy a tender swelling in the muscle which gradually became hard and painless. Not many years ago such tumours were thought to be evidence of congenital syphilis, but inspection of one by Dr. Frederick Taylor revealed their exact nature. A surgeon is never justified in assuming that because a tumour of the sterno-mastoid disappeared when the child was being treated by mercury it was necessarily syphilitic.

As a rule both parts of the muscle—the sternal and the clavicular—are implicated in the shortening, though sometimes only one is concerned. And it often happens that when only one part of the muscle apparently needs division, after the surgeon has cut it he finds that the remaining part also has to be severed.

As a result of the permanent shortening of the muscle the mastoid process is drawn down towards the top of the sternum, so that the ear of the affected side approaches the shoulder, whilst the chin and face are turned towards the opposite side. And when the attempt is made to place the head and face in an improved position, the rigid muscle is brought out into strong relief, and the shoulder is drawn up to meet the ear.

The shoulder of that side is permanently raised, and from the constant dragging of the shortened muscle the due development of that half of the head and face is checked, so that the parietal eminence, the half of the frontal bone, the malar bone, and that side of the lower jaw may be markedly smaller than they should be, whilst the ear and the commissure of the eyelids and of the lips may be dragged downwards. A similar arrest of development may affect the sides of the vertebræ, so that a lateral curvature of the cervical column is produced, the concavity being directed to the affected side, with, in several cases, a secondary curvature in the opposite direction in the dorsal region of the spine.

Torticollis Anterior.—In certain very rare instances symmetrical contraction follows rupture of both sterno-mastoid muscles, with the result that the chin is rigidly drawn down towards the top of the breast-bone. Both muscles being equally shortened the head cannot be inclined to either shoulder, nor the face turned to the right or the left, so the deformity cannot be called *double wry-neck.* A very suitable name for it, however, is torticollis anterior.

Persistent deviation of the head and neck may also be the result of inflammation of the cervical glands; of a shortening of the sterno-mastoid following suppurative inflammation of that muscle or of the tissues near it; of contraction of the scar following a severe burn of the neck; of periostitis of the cervical vertebræ; of tuberculous disease of the vertebræ themselves, or of the synovial joints between the base of the skull and the first and second cervical vertebræ. (Hysterical contraction of a sterno-mastoid is unlikely to occur without other suggestions or manifestations as to its exact nature.)

Wry-Neck due to Vertebral Disease.—Of all the foregoing conditions the most important is tuberculous inflammation of the cervical vertebræ or of the joints in the highest region of the neck. (See "POTT'S DISEASE," vol. xi. p. 316). The symptoms of tuberculous disease of the spine are not infrequently misinterpreted and are ascribed to "rheumatism," but the deformity may be distinguished from ordinary wry-neck by the fact that pressure upon the top of the head causes distress, and that even in a limited degree the patient is unable to move the neck or to shake or nod the head; and that there have been for many weeks, or even months, complaints of obscure pains in the head, neck, or chest, the result of pressure upon the roots of the nerves passing out through the diseased region of the spine. In wry-neck due to disease of the vertebræ no movement is permitted except with apprehension and pain, whereas in the other case movements are free and painless within certain limits. To mistake cervical caries for common wry-neck may involve very serious consequences.

TREATMENT OF WRY-NECK.—For the treatment of wry-neck which is due to permanent shortening of the sterno-mastoid nothing short of a cutting operation can suffice, and the sooner that it is efficiently carried out the better. The treatment by drugs, electricity, or massage, can end in nothing but disappointment.

Operation for Wry-Neck.—The child should be anæsthetised and placed upon an operating table, or upon a folded blanket laid upon a low chest of drawers or a narrow table. The shoulders should be slightly raised on a firm pillow, and, whilst the head is drawn towards the opposite side, a nurse should pull down the arm of the affected side so as to render the muscle tense and prominent. The head should be held and steadied by the chloroformist, so that the assistant may have both his hands free. It is hardly necessary to say that the skin of the neck, and everything that is to come in contact with the wound, should be aseptic.

Division of the sterno-mastoid may be performed either by subcutaneous tenotomy, or by what is known as the open method.

The subcutaneous method consists in making a puncture in the skin at the root of the neck, close to the side of the contracted tendon, and introducing a blunt-ended tenotomy knife through the puncture and beneath the band, which is then divided by a sort of sawing motion up towards the skin. Traction being made upon the head the tendon yields in a definite and obvious manner. The movements of the knife are checked just before the skin is reached, the actual progress of the knife being estimated partly by the finger placed on the skin over the point of section.

After the one piece of the muscle—the sternal origin, for instance—has been divided, and further traction is made on the head, the remaining portion of the muscle is generally found to be in need of division, although it may not previously have appeared to be shortened.

The clavicular head is then divided in a manner similar to the preceding, and generally through a separate skin-wound. In a small proportion of cases, however, only one portion of the sterno-mastoid may require section.

The operation being finished, a small pad of lint is fixed over the punctures, the head being left in the old position until they are soundly healed.

Subcutaneous tenotomy was introduced in the days when suppuration commonly followed the infliction of an open wound on account of septic micro-organisms having been allowed to contaminate the freshly cut surfaces. The smaller the wound the less the chance of septic infection. Division of the muscle through the smallest possible wound was, therefore, almost a necessity a few years ago. But the subcutaneous method had this great disadvantage, that when the knife was working out of sight and in a very dangerous area the surgeon could not know exactly what he was dividing. And so it came about that a large anterior or external jugular was sometimes wounded, with an alarming, if not a fatal result. Walther states that whilst performing the subcutaneous operation Robert cut the external jugular vein, and that Volkmann wounded the internal jugular. I also once had an alarming experience whilst operating by the subcutaneous method at The Children's Hospital a good many years ago, the child nearly dying either from entrance of air into a wounded vein, or from grave shock which was produced in some other manner. At any rate, there was so great a welling-up of blood that I had immediately to apply firm pressure over the spot and to send the child back to bed with the tenotomy unfinished. And it was with no little apprehension that I set about the completion of the operation a few days later. However, no further trouble ensued, and the child was in due course completely cured.

The open operation has now almost entirely taken the place of the subcutaneous method. First of all the skin at the root of the neck is carefully prepared and rendered aseptic. An incision, long enough to give free access to the deeper parts, is then made over the contracted muscle about a finger's breadth above the upper border of the clavicle, the superficial fascia, platysma, and deep fascia being divided layer by layer, and bleeding vessels being secured by clip-forceps. Then the origin of the muscle is reached, and its fibres are cut through until the layer of the cervical fascia which lies beneath it is fully exposed. This also may need some touches of the knife before the head can be drawn into the improved position.

All the rigid bands of muscle and fascia being divided, a wide gaping wound is made, in the depths of which the surgeon may see the subclavian vein heaving with the respiratory movements, to say nothing of the swollen jugulars and their tributaries. If in the course of the operation a branch of vein has to be divided, it is first leisurely and securely dealt with, for the surgeon sees every structure before he cuts it, and has ample opportunity for recognising it. And this, surely, is a great comfort.

Before the wound is sutured it is well to have the head vigorously bent over to the other side, whilst the face is made to rotate to the affected side in order to stretch all the shortened structures to the utmost, and thus to begin the corrective treatment whilst the child is under the anæsthetic. Force thus vigorously applied is extremely helpful.

When every resisting band has been divided with the point of the knife, or scratched through with a director, and all bleeding has been stayed, the skin-wound is closed with an aseptic suture of horse hair or silk-worm gut, and dressed with a seal of gauze and collodion; or an aseptic pad is secured over the place by a bandage which runs round the neck and under the armpit, and the child is put to bed with the head steadied, in a slightly improved position, between two large sand pillows.

Sometimes after the sterno-mastoid has been divided, and bands of the deep fascia have been scratched through or efficiently stretched, the border of the trapezius or of some other cervical muscle may be found short and rigid, but this complication can easily be put right subsequently by massage.

It is occasionally urged that, in the treatment of wry-neck in a girl who will eventually have to wear low-necked dresses, the open method is not advisable, in that it will be followed by a permanent, and possibly an unsightly scar. But, in my opinion, this is a matter of comparatively small importance when the question of the effectual and safe performance of a necessary and a delicate operation is at stake. As regards the possible disfigurement of the scar by a keloid thickening, this is likely to occur only in a tuberculous subject. And should it occur, it may be trusted to disappear as the child grows in years and in health.

As regards the respective merits of the subcutaneous and the open operations, I would say that for some years I practised the subcutaneous method, but that I have long since entirely discarded it for the open operation, and I would not revert to it under any consideration. Redard goes so far as to maintain that the great progress which has been realised in the treatment of wry-neck is chiefly due to the general adoption of the open method.

In certain cases resection of a piece, or even of the whole, of the sterno-mastoid has been practised. Personally, I have never seen a case in which I could have thought so severe a measure to be necessary or justifiable.

The after-treatment should be begun as soon as the stitches have been removed, which is, as a rule, well within the week, though if for any cause the healing of the skin-wound has been delayed, stretchings and manipulations must be postponed. However, if the division of the muscle has been thoroughly carried out, the divided ends having been left, perhaps, far asunder, the delay of a few days is of no serious import.

The operation having been thoroughly performed, no splint, "brace," or apparatus of any kind is needed, not even in the case of a young adult. If the patient be a very young child the rectification of the position of the head and the straightening of the cervical column must be gradually effected by the surgeon's hands, and in this he may obtain much assistance from a competent nurse or an intelligent parent. At night the child should be made to lie upon the affected side, with the head so placed upon a thick and firm pillow that even during sleep the treatment is not entirely remitted.

If the child be old enough to walk he should be encouraged to go about with a shot-can, or some other weight, hanging in his hand so as to pull down the shoulder to the utmost, and he should also be made to incline his head over to the opposite side. And many times during the day this drilling may be supplemented by firm massage and manipulations of the neck. Rigid retentive apparatus of all sorts would be prejudicial, in that it would prevent the needful exercise of the muscles.

The after-treatment demands long-continued care and patience; it is obvious that deformities extending secondarily to the bones themselves cannot be corrected by the mere cutting of a contracted muscle.

If the patient be capable of taking an intelligent interest in the after-treatment of his case, he and his surgeon will be able to plan all sorts of games or exercises which will have the effect of stretching the tissues on the short side of his neck, and hurrying on the complete effacement of the deformity.

Spasmodic Wry-Neck

As the result of central nervous irritation in adult persons, the sterno-mastoid may be implicated in persistent rhythmic contractions, which, by violently jerking the side of the head and neck, may cause considerable pain and distress, or seriously interfere with the usefulness and comfort of the patient. Spasmodic wry-neck has to be distinguished from hysterical contraction of the sterno-mastoid, which, however, is more likely to occur in a youngish woman.

Treatment.—As regards the treatment of spasmodic wry-neck all drugs, inclusive of arsenic and strychnia, are disappointing, and electricity has not been found of service. Unfortunately, time, the great healer, passes these cases by, and nothing remains but for the surgeon to resect a portion of the spinal accessory nerve. Possibly, also, he may also have to take away branches of the cervical nerves entering the muscle in order to insure complete relief.

For *resection of the spinal accessory nerve* a three-inch incision is made from the tip of the mastoid process down the anterior border of the sterno-mastoid. The edge of the muscle is lifted well up, and the posterior belly of the digastric muscle exposed; the nerve then is seen passing from beneath it into the deep aspect of the sterno-mastoid. It may be necessary to slacken the muscle and turn it well out in order to expose the nerve, which is, however, a large and conspicuous trunk. On pinching it in the forceps spasmodic contractions of the sterno-mastoid and trapezius result, and reveal its identity beyond a doubt.

On the first occasion of the spinal accessory nerve being resected for the relief of spasmodic wry-neck, the surgeon (de Morgan) sought for it at the posterior border of the sterno-mastoid, and, following it upwards and forwards through the muscle, divided it above the point of entrance, which is on a level with the angle of the lower jaw. The usual operation now, however, is to seek the nerve at its entrance into the muscle. There is no great difficulty in the operation if the surgeon makes a long incision, beginning it as high as possible, and lifting the muscle well up.

Excision of the posterior branches of the cervical nerves is rarely called for in the treatment of spasmodic wry-neck, and it should not be undertaken unless it is certain that the spinal accessory nerve has undoubtedly been resected, and that that measure has proved insufficient.

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X-Rays, Finsen Light, and High Frequency Currents.

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Their Nature and Production

Though seven years have elapsed since Prof. Röntgen made his wonderful discovery very little has comparatively been since added to our knowledge as to their physical nature or as to our means of generating them.

Though their nature is still unknown, evidence has been accumulating in favour of Sir George Stokes' theory, that they are due to irregular impulses in the ether comparable acoustically to a noise. Thus it has been shown that they travel with the velocity of light (Blondlot), but they differ from ordinary light in not being capable of regular reflection, refraction, or polarisation;[1] they can, however, excite fluorescence, affect a photographic plate, and discharge an electrified body, but these are the chief properties of violet and ultra violet light, so that the Röntgen rays more closely resemble ultra violet light than ordinary visible light.

There are altogether four chief qualities of radiation which are used in medicine, and they can be tabulated as follows:—

1. Radiant heat rays (invisible).
2. Ordinary light.
3. Ultra violet light (invisible).
4. Röntgen rays (invisible).

The Effluve, or brush discharge, produced by high frequency currents has some of the properties of ultra violet light. About three of these forms of radiation a good deal is known; thus if we examine the spectrum of white light, we find it consists of seven colours which are arranged with the radiant heat rays and the ultra violet rays as follows:—

Invisible.—Radiant heat.

Visible Spectrum.—Red, orange, yellow, green, blue (Finsen rays), indigo (Finsen rays), violet (Finsen rays).

Invisible.—Ultra violet (Finsen rays).

The rays are arranged in this table according to their wave lengths; thus the radiant heat rays have the longest wave length and the ultra violet the shortest. Our knowledge is not at present sufficiently definite to permit us to assign a position in this table to the Röntgen rays, but they have, as we have seen, the leading properties of the invisible ultra violet rays. They differ chiefly in their powers of penetration. Ultra violet rays have but little penetrative power as regards our tissues, and are absorbed by the thinnest film of blood, while the Röntgen rays pass through our skin and soft structures with great facility, but throw shadows of the bones. Transparency to Röntgen rays is a question of density; all light bodies are transparent and all heavy bodies are opaque. In the following table of densities an attempt has been made to roughly indicate in order the relative transparency of bodies, but it must be remembered that transparency and opacity are only questions of a degree, and that a thin film of an opaque body would permit some of the rays to go through, while a thick film of a transparent body would cast a shadow.

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[1] Blondlot has recently shown that the rays are polarised.

Quite opaque.—Platinum, mercury, bismuth, lead, silver.

Opaque.—Copper, iron, zinc.

Semitransparent.—Flint glass, aluminium, quartz, crown glass, calculi of lime oxalate, calculi of phosphates, bone, calculi of uric acid.

Transparent.—Biliary calculi, cutaneous tissue, tendons, arteries, muscles, blood, veins, nerves, brain, pus, urine, milk, water, human fat, wood, etc.

The above table is one of the order of relative transparency; thus calculi of oxalates are more opaque than calculi of phosphates or of urates. The order of transparency is not always the same as the order of density; thus uric acid calculi are more dense than calculi of phosphates, but are more transparent (Swain). Biliary calculi have much the same transparency as the skin, and are therefore very difficult to photograph *in situ* unless there be a thick mass of them. In actinic effect the Röntgen rays are far behind violet and ultra violet light; it has been calculated that they have only one-sixtieth the actinic effect of a candle. In producing fluorescence and in discharging electrified bodies they are, however, more powerful; they cause barium platinocyanide to fluoresce with a yellowish green, while ultra violet light causes it to shine with a brilliant green. The Röntgen rays will discharge a positively or a negatively charged body; the ultra violet light, unless of high refrangibility, will only discharge a negatively electrified body provided with a clean zinc or other special metallic surface, and will only do this at a comparatively short range. Further, the Röntgen rays appear to have no bactericidal effect, while ultra violet light can kill cultures of the staphylococcus pyogenes aureus in four seconds.

Lastly, they differ in their clinical effect; ultra violet light produces a transient hyperæmia or erythema, and sometimes some pigmentation, the granulomatous tissue of lupus has in time its vitality destroyed and undergoes degeneration (Macleod), but under no circumstances does destruction of healthy tissue follow.

The Röntgen rays, if pushed, or in susceptible people, will produce severe dermatitis and intractable ulcers; changes in the nails, falling off of the hair, and pigmentation are common. The Röntgen ray dermatitis is a cumulative effect, and it may not come on until a week or more after the cessation of the exposures, hence great caution is necessary. A patient may have had half a dozen exposures of five to ten minutes each, and may go away with apparently no risk of dermatitis, but in a few days' time may suffer from severe smarting and burning sensations. The skin becomes red, then dusky purple and œdematous, and it may give way and be followed by an indolent suppurating sore. This dermatitis may be prolonged, and it will not yield to remedies.

The pathological changes are mainly confined to the blood-vessels, which become dilated and degenerated; thrombosis follows, and dense bands of connective tissue are formed. The hair follicles and sebaceous glands disappear. See also p. 516.

MODE OF PRODUCTION OF THE RÖNTGEN RAYS

The rays, so far as we are at present aware, can only be produced by passing electrical discharges through highly exhausted vacuum tubes. In time to come we may, perhaps, be able to make use of the radiation of certain uranium compounds, or of radium; their bodies yield a constant radiation akin to the X radiation, but in feeble amount.

At present we require electricity of high potential and properly constructed vacuum tubes.

There are two chief methods for producing the electricity: the one method is to make use of a static influence machine, the other is to use an induction coil.

There are several kinds of influence machine, the Holtz, Voss, Wimshurst, Pidgeon, and Gaiffe.

In this country the Wimshurst is in most use, but it is probable that the Pidgeon will displace it.

Whichever machine be chosen it is essential that the plates be of large size—20-36 inches in diameter—and many in number. A Wimshurst (Fig. 1) machine for this purpose might consist of ten 24-inch plates, but larger plates would be an advantage. The plates are best made of a special quality of glass. Gaiffe uses ten ebonite plates, and the advantage of this is that there is no risk of breaking the plates by a too rapid rotation; thus owing to the great rate at which the plates can be revolved the output is considerably greater. The objection to the use of ebonite is that it is liable under the influence of light to lose its surface insulation, and also to warp, and therefore for a permanent installation, and where portability is not concerned, glass is to be preferred.

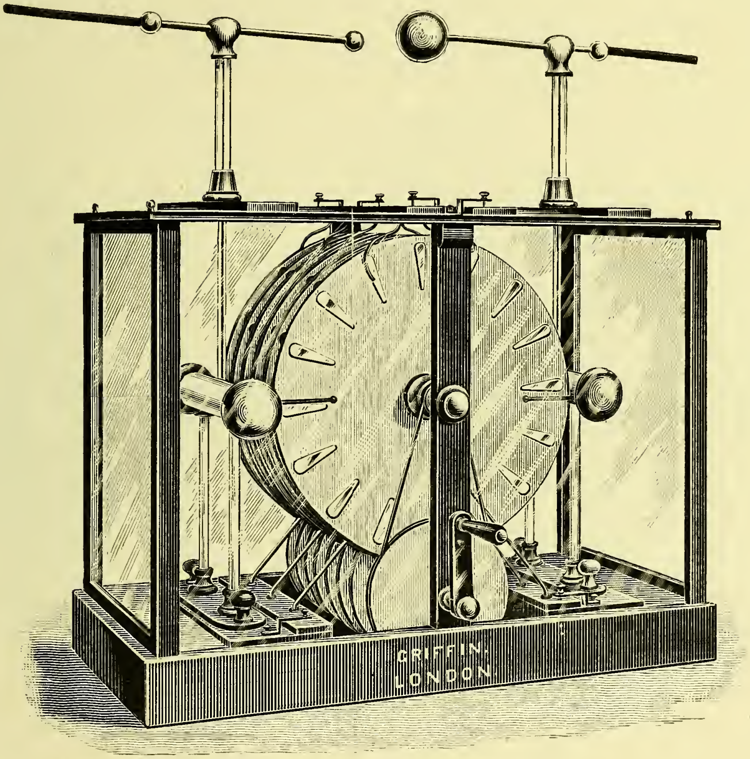

FIG. 1.—Wimshurst influence machine. Griffin.

The terminals of the ordinary vacuum tube are not very suitable for use with a static machine; it is better to have a tube with ball-shaped terminals, and to allow a small spark gap to intervene on either side between the wires attached to the influence machine and the terminals of the tube. A good deal will depend upon the proper arrangement of these spark gaps, and their lengths should be varied until the tube yields the best radiation; sometimes the tube will work better without them. For Gaiffe's influence machine a special tube with cylindrical terminals called the Chabaud-Villard is supplied. These sources of difficulty, together with the trouble often occasioned by the capricious yield of the influence machine, are absent when an induction coil is made use of. The Leyden jars of the influence machine should be disconnected, otherwise a succession of very bright flashes will be produced instead of a continuous discharge. An advantage of the influence machine is that, unless punctured by a stray spark, the life of the tubes is longer, because the current passed through them is smaller and the heating effect less. There is also an absence of flickering, so that for screen work they are less tiring to the eye. It is also an advantage to be able to do without accumulators or primary batteries, and to generate one's own electricity; still, on the whole, most operators, including the writer, prefer the induction coil.

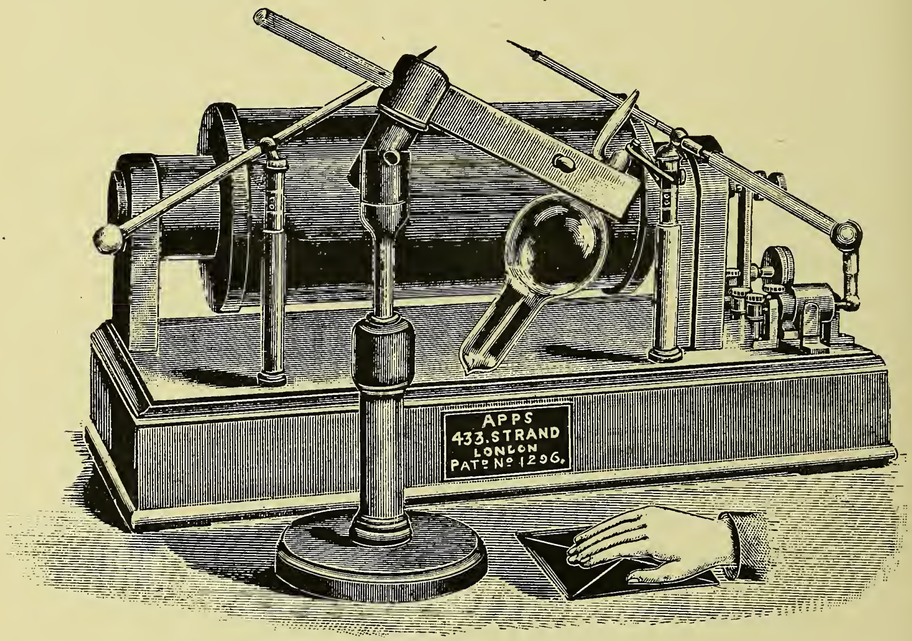

Fig. 2.—Induction coil. Turner's *Med. Electricity.*

If the induction coil method be preferred, a set of accumulators, or a primary battery, or a connection to the electric lighting mains will also be required.

The smallest induction coil which will be found of much use is one with a six-inch spark, a more satisfactory instrument will be one with a ten-inch spark (Fig. 2), and coils with eighteen or twenty-four inch sparks are sometimes used. A great deal depends upon the quality and construction of the coil, and the instrument should be suited to the source of electric supply; thus a coil wound to run off a few accumulators will not yield the best effects when fed by a high voltage current from the mains. A good maker of coils is Apps, 433 Strand, London. When electrolytic interrupters are used it is sometimes an advantage to be able to vary the self-induction of a coil; this can be done by altering the connections of the layers of the primary winding. Schall, 55 Wigmore Street, London, supplies a German induction coil in which the terminals of the four layers of the primary wire are brought outside (Fig. 3), and which can be connected together either—

1. All in series,
2. All in parallel, or
3. Two layers in series, and the two groups in parallel.

In the first case the self-induction is at a maximum and the coil is suitable for soft tubes; the current at make is completely suppressed.

In the second case the self-induction is at a minimum, the current at make is not completely suppressed, but the full length of spark at break is obtained, and the coil is suitable for hard tubes.

In the third case an intermediate condition obtains.

In addition to the coil a current interrupter will be required; the old-fashioned Neef's hammer or vibrating spring which usually forms part of the coil can be used when the coil is fed by a few accumulators, and when intense effects are not required, but it cannot be used when the coil is attached to the electric light mains, and under all circumstances a separate motor interrupter is advantageous; still it is better not to buy a coil unless it is provided with a Neef's hammer, for the latter is often useful as a stand-by, and it is also the most portable of interrupters.

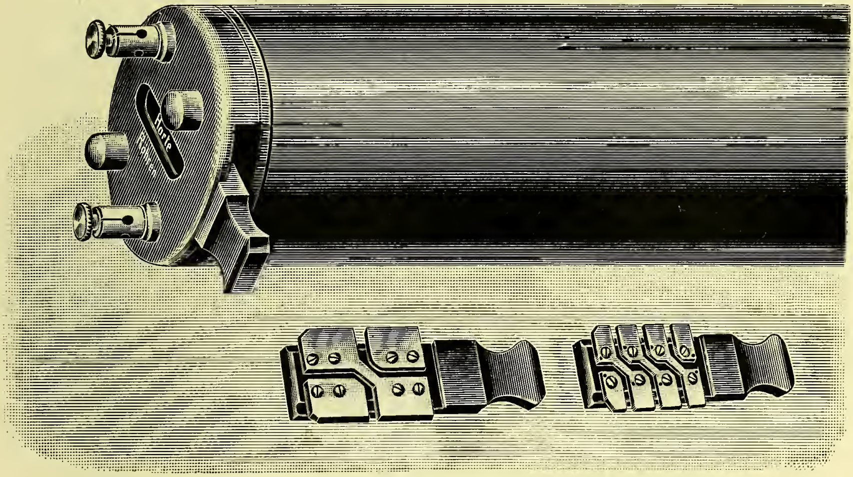

Fig. 3.—Arrangement for altering self-induction of coil. Schall.

The chief forms of motor interrupters can be classified as follows:—

1. Mercurial { Dipping contact, Mackenzie Davidson, mercury jet or turbine.
2. Electrolytic—Wehnelt, Simon Caldwell, Campbell Swinton.
3. Rubbing contact between solids { Dawson Turner, Contremoulins-Gaiffe.

All these interrupters can be used either with high voltage currents from the mains or (excepting the electrolytic group) with low voltage currents from accumulators.

1. The simplest motor-driven mercury interrupter is the one with a vertical dipping contact (Fig. 4).

The advantage of this instrument is that it is simple, it is easily kept in order, and it only requires a small amount of mercury. It is, however, less rapid than the succeeding instruments.

In the Mackenzie Davidson interrupter (Fig. 5) the contact is made by an inclined rotating paddle which alternately dips into and out of the mercury. The paddle shaft is driven by a band attached to the motor shaft so as to insulate it from the motor, and to permit the motor to be fed by the accumulators that are supplying the induction coil. This instrument having a rotating instead of a reciprocating motion can be run very

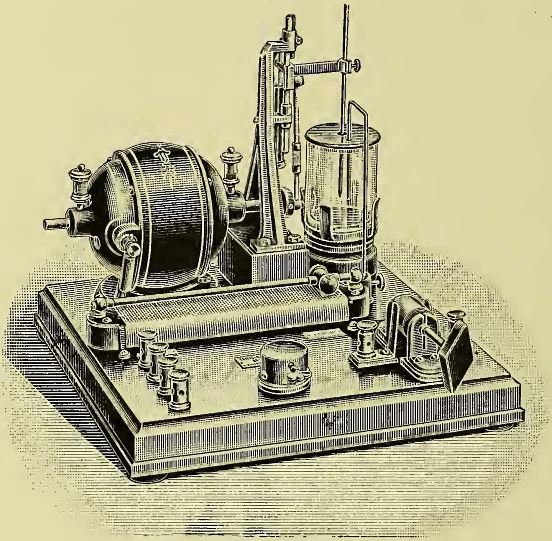

Fig. 4.—Dipping contact interrupter. Schall.

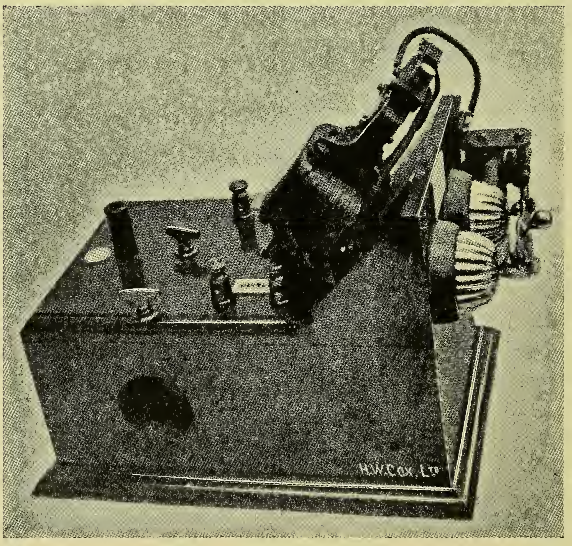

Fig. 5.—Mackenzie Davidson interrupter. Walrh's *Röntgen Rays.*

rapidly, and it is one of the best interrupters known. A disadvantage is the very large amount of mercury required.

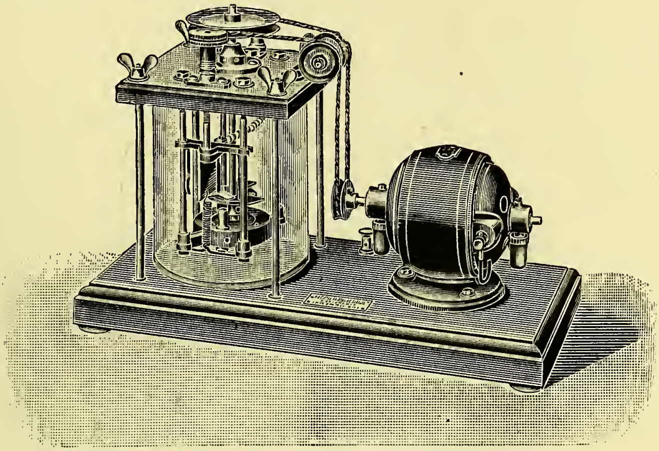

FIG. 6.—Mercury jet interrupter. Turner's *Med. Electricity.*

In the mercury jet interrupter (Fig. 6) there is a small centrifugal pump below, which throws up a constant fountain of mercury along which the current passes; the current is broken by the interposition of two

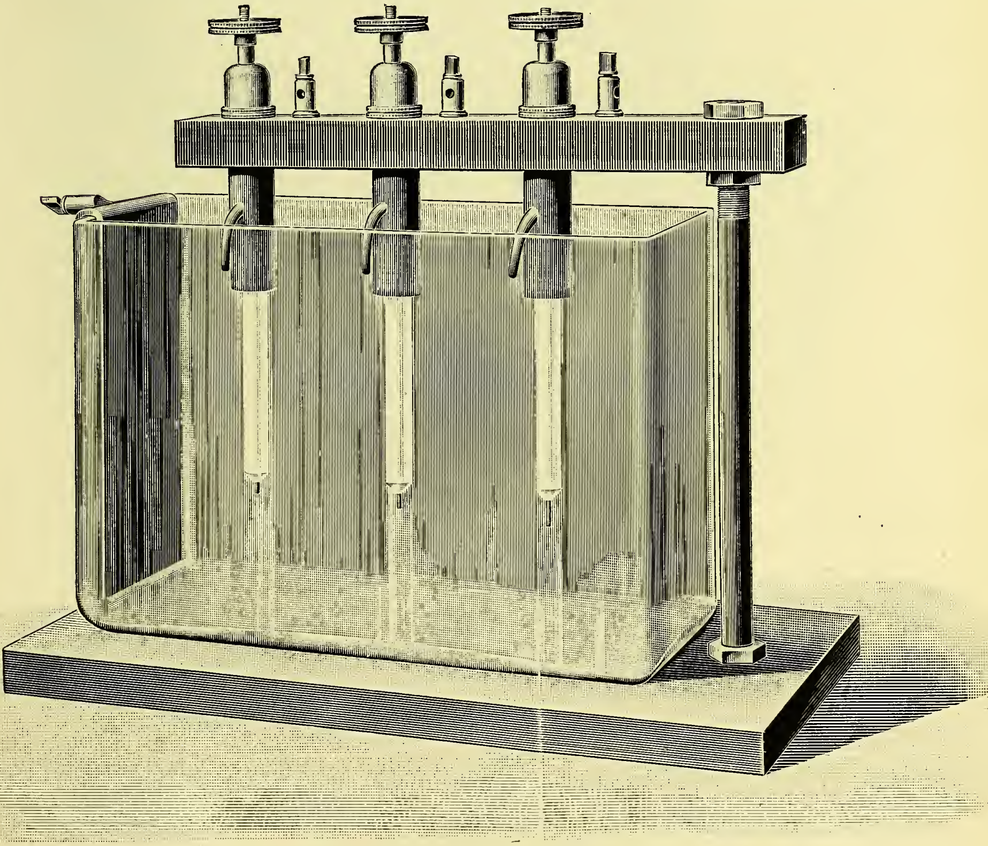

FIG. 7.—Wehnelt interrupter, new pattern. Schall.

insulating fibre arms whose plane of rotation is at right angles to the direction of the jet. This is also an excellent interrupter, but it suffers from the disadvantage of requiring a large amount of mercury. This makes it very heavy, in fact, the complete instrument is as much as a man can conveniently carry.

All the above-mentioned mercurial interrupters suffer from certain defects which appear to be inseparable from the use of mercury; the mercury becomes oxidised, pulverised, and churned up with the paraffin or alcohol so that the insulating properties of the paraffin are impaired and a complete break is not obtained; further, in the case of the mercury jet, the emulsified mercury is thrown up and deposited upon the insulating fibre supports, which have accordingly to be cleaned—not a pleasant operation while a patient is waiting. Care must, therefore, be taken to keep the mercury in these instruments clean by washing with water or dilute sulphuric acid.

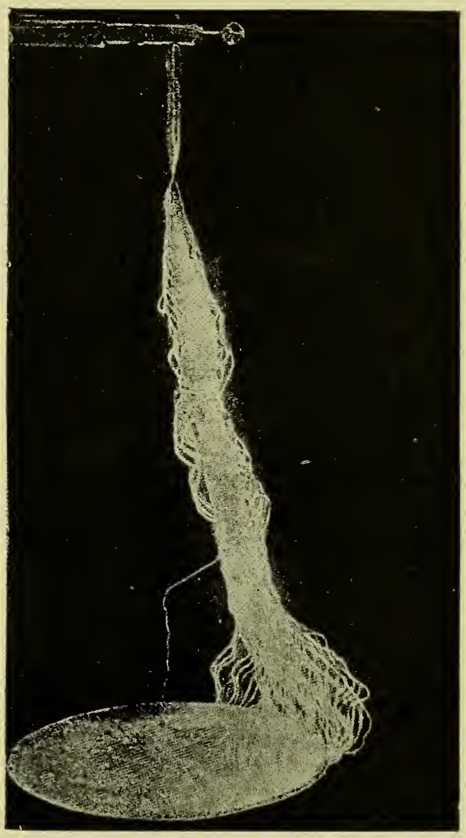

Fig. 8.—Wehnelt spark. Turner's *Med. Electricity.*

2. A new group of interrupters were first introduced by Dr. Wehnelt (Fig. 7), and we owe modifications of the original instrument to Simon Caldwell, Campbell Swinton, and others.

The principle of the instrument is electrolytic. Into a large jar of dilute sulphuric acid are placed a good-sized lead plate and a small platinum wire, which can be made to project through a tight-fitting aperture; the diameter of the platinum wire and the amount of projection are important, and in later instruments three or more platinum wires of different diameters (1, 2, and 3 mm.) are provided (Fig. 7). Any one of these can be used as desired to suit the conditions of the voltage. The lead plate must be made the kathode, and the platinum wire the anode. The interrupter can be used when the voltage of the current supplied is not less than thirty (fifteen accumulators), and it can be used directly from the electric light mains (100-230 volts). No mechanical interrupter can approach this one in the rapidity of the interruptions, and the discharge at the secondary terminals takes the form rather of a continuous flame than of a succession of sparks (Fig. 8). It is thus exceedingly powerful. The condensers of the coil should be detached during its use. It suffers from the disadvantage of not being wholly reliable; sometimes it will not work steadily, it tires and the acid grows hot, and the powerful discharges set up overheat the anode of the tube. The interruptions are perhaps due to bubbles of gas produced by electrolysis at the anode, the spheroidal state may also play a part. The tiny bubble of gas will cut off the current, but as soon as the current stops the bubble is absorbed and the current starts again. In other forms of this break the small platinum wire is replaced by a lead plate, and the interruptions are produced by forcing the current to pass through a small aperture in a plate of porcelain which divides the cell into two parts. The Wehnelt break is of service when it is desired to give a very short exposure, as in photographing the teeth.

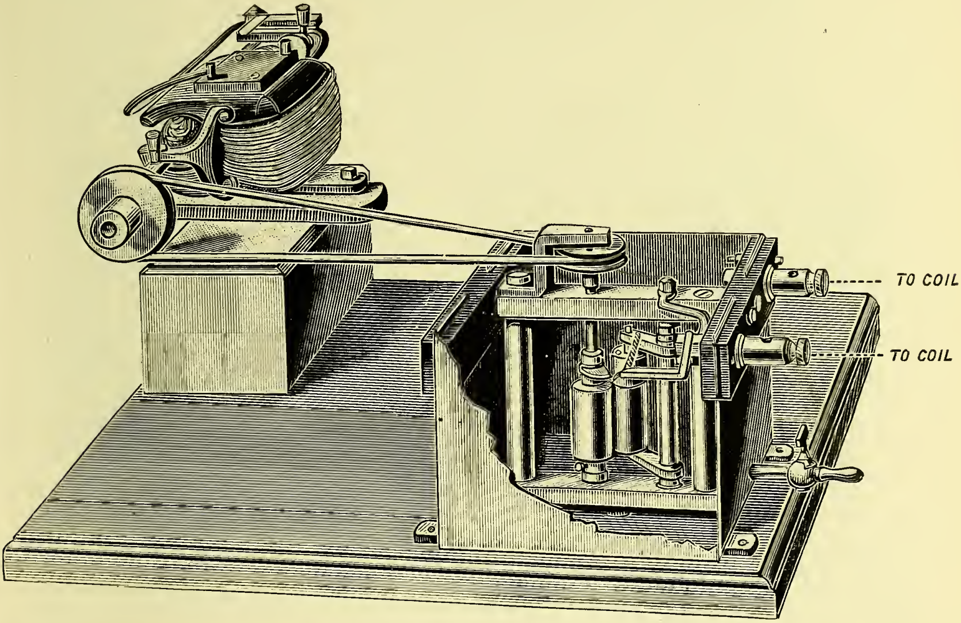

FIG. 9.—Dawson Turner interrupter. Turner's *Med. Electricity*.

3. More recently rubbing contact interrupters between solids have been introduced by Dawson Turner and Gaiffe.

In the Dawson Turner break (Fig. 9) there are two rollers of brass or copper, which are alternately brought into contact and separated by a small electric motor; as the rollers rotate the break is constantly made at a fresh point, and the burning away is distributed evenly all round. The rollers must be immersed in paraffin, alcohol, or water. If the noise made by this interrupter be not objected to it will be found a satisfactory and portable instrument; there is no possibility of short circuiting, and there is no mercury to be oxidised and thrown into waves.

Contremoulins and Gaiffe have constructed a rubbing contact interrupter between copper and carbon. A tube of copper is divided longitudinally into two halves, and is rotated by a motor; two carbon brushes are pressed by springs against the surface of the copper, the current will pass when both brushes are on the same half of the copper, and will be broken when they are not. By moving one of the brushes the contact can be increased or diminished. The apparatus is immersed in alcohol or paraffin. This is a silent instrument, but as the burning away always occurs at the same place the brushes and copper cannot last very long.

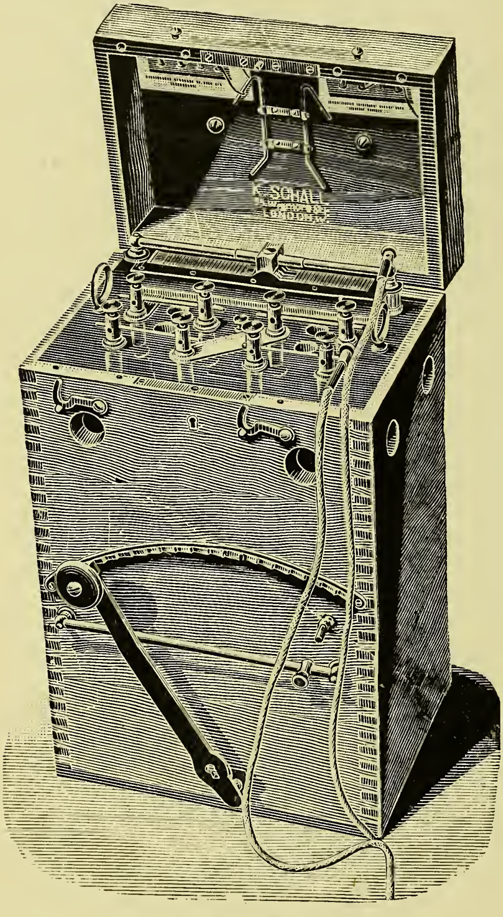

Fig. 10.—Bichromate battery with lifting arrangement. Schall.

The supply of electricity for the coil may be obtained from primary cells, from accumulators, or by a branch circuit attached to the electric light mains. Primary cells should, if possible, be avoided; if, however, circumstances compel their employment, five to ten large bichromate or Bunsen cells are the best; the bichromate cells (Fig. 10) may be purchased in sets of five provided with a lifting arrangement, and the zincs should only be allowed to remain in the acid solution during use of the coil. The solution will require frequent renewal, and the zincs must be kept well amalgamated. Bunsen cells give a more continuous current, but they have to be set up before and dismantled after every use. Accumulators are much to be preferred; five to ten will be found sufficient; the "q" type of the Electrical Power Storage Company or the lithanode are so sealed as to be fairly portable. Accumulators can only be employed when there is some means at hand for recharging them. If the electric light mains (continuous current) are laid on, the coil may be fed by placing it on a branch circuit with a sufficient resistance, but one of the high voltage breaks will be required. Schall sells complete resistance boards for this purpose (Fig. 11). Though this is the simplest and least troublesome method, it is not so advantageous as the use of accumulators: a larger current strength can be obtained from the latter and a higher voltage from the former, and the large current strength is to be preferred; further, the Neef's hammer is available with accumulators.

Röntgen ray tubes have been recently improved in strength and durability, and in means of keeping the degree of vacuum constant. In its simplest form the tube consists of a cylinder or bulb of glass through the ends of which platinum wires pass; the latter are continued as aluminium rods. One of these, the kathode, terminates in a small concave mirror; the other, the anode, is a thick disk of platinum inclined at an angle of 45° to the axis of the kathode, and at a distance a little beyond the principal focus

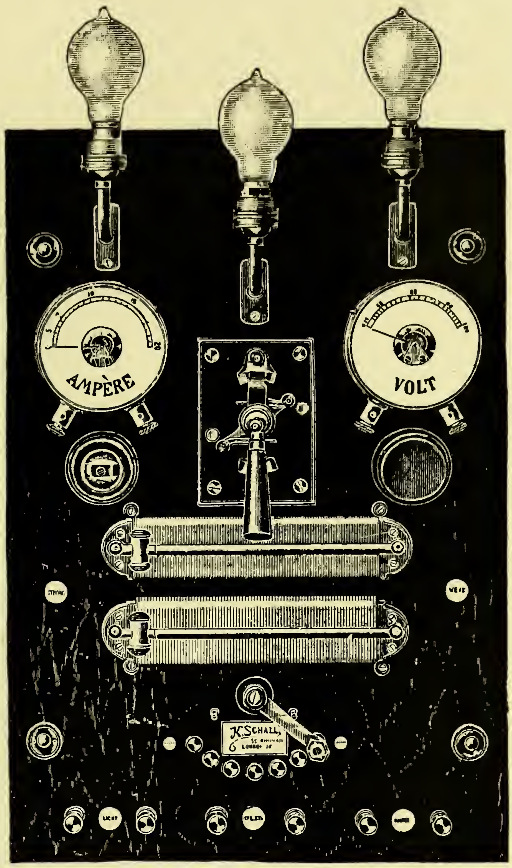

Fig. 11.—Switch board for supplying coil from the main. Schall.

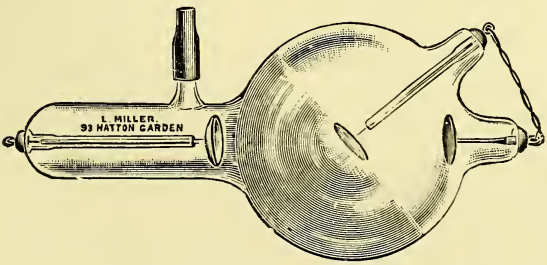

Fig. 12.—Röntgen ray tube. L. Miller.

of the concave mirror. The tube is exhausted to a very high vacuum. The glass of which the tube is made must be quite free from lead. When the discharge from an induction coil is passed in the right direction through such a tube, that part of the wall of the tube which is opposite to the anode will shine with a greenish yellow phosphorescence of hemispherical form; if the tube be wrongly connected the green light will be patchy and irregular.

Modern tubes have three electrodes and sometimes arrangements for varying the vacuum. The Chabaud-Villard tube for Gaiffe's influence machine is provided with such a means. A good maker of tubes is Hirschmann of Berlin (Fig. 13). At one end of the tube is an arrangement for admitting air, and at the other end one for withdrawing air; either can be used by causing the electricity to pass solely through the particular arrangement. Such a tube is a great advantage, for most tubes unless punctured become gradually useless through their electrical resistance rising owing to a too high vacuum. Another good maker of tubes is Mueller of Hamburg; his tubes are sold by Cox of Cursitor Street, London, and by Leslie Miller, Hatton Garden, London. To Mueller's tube was awarded the gold medal of the Röntgen Society in 1901. The conditions of this competition serve to bring out what are considered to be the important points in a Röntgen ray tube. These are:—

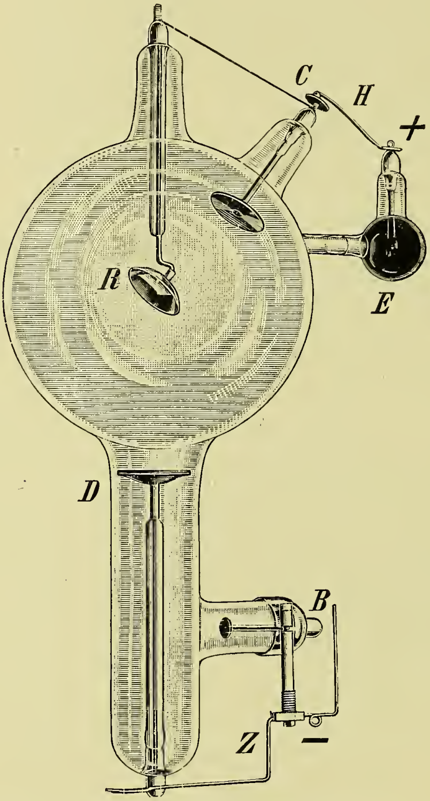

Fig. 13.—Röntgen ray tube with arrangement for altering the vacuum. Hirschmann.

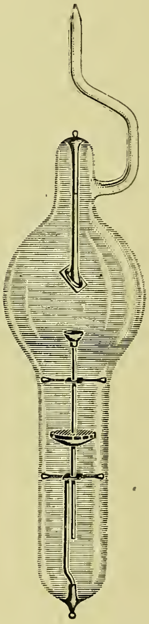

Fig. 14.—Röntgen ray tube with movable cathode. Dawson Turner.

(1) Definition.
(2) Penetration.
(3) Photographic effect.
(4) Price.

The predominant requirement was that the tube selected as the best should be practical. About 75 per cent of the tubes failed to satisfy the required tests for definition, and in the opinion of the jury the attention of makers of tubes should be drawn to this defect, because unless a tube defines well, all other advantages it may possess are to a great extent valueless for most of the purposes to which X-rays are put.

The tubes which stood the test for definition were subjected to a very severe trial for penetration and photographic effect, and the jury were glad to be able to report that a much higher standard of excellence was attained in this respect than in that of definition. The element of price did not require very serious consideration. The prices of the tubes sent in varied from £4, 5s. to 16s. Many of the high-priced tubes were eliminated by the first test, and the tube which best satisfied all the tests applied by the jury was the one sent in as Cox's Record tube, made by C. H. F. Mueller of Hamburg (*Archives of the Röntgen Ray*, August 1901). The only fault the writer has to find with these tubes is that the resistance seems to increase rather rapidly. The only satisfactory way of reducing the resistance of a tube is to lower the vacuum, and if the tube is not provided with a means for letting in more air it should be returned to the maker, who will first allow it to refill with air and then re-exhaust it. A strictly temporary method of lowering the resistance of a tube is to heat it with a large spirit flame; the flame should be passed boldly and rapidly all over the tube; this remedy only serves to aggravate the existing disease, for though effectual for the moment the resistance will be found afterwards to be higher than ever; other methods suggested for lowering the resistance are not satisfactory.

Tube holders, fluorescent screens, and photographic plates are also required. Convenient tube holders are supplied by Schall (Fig. 15); a table tube holder should be about 14 inches in height and its arm about 2 feet in length. One of the best makers of fluorescent screens is Johnson and Matthey of Hatton Garden, London; a convenient size is 14 × 16 inches. The screen is coated with barium platino-cyanide on one side and with black paper on the other; the coated side should be protected by a glass or celluloid cover.

Any good make of photographic plate will suffice; some of those the author has used are those supplied by Lumière, Edward's Cathodal, Paget, Imperial, and Ilford, and Wrotten and Wainwright. It is important to stick to the same plate and developer. The plates should be fresh and be coated with a thick film. The author (see *Electrician*, February 1897) has not found any advantage result from using very rapid plates, though a shorter exposure may suffice the resulting picture is not so good.

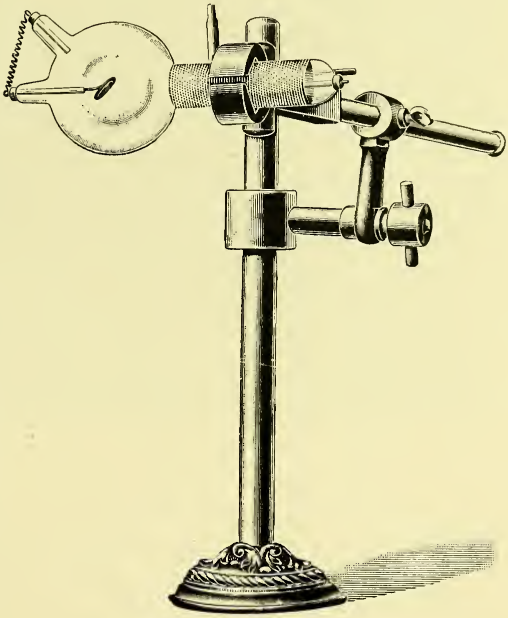

FIG. 15.—Tube holder for tube.

To protect the plates from light they should be enclosed in light-tight envelopes, or in a specially made case, and the object to be photographed should be placed in close contact with the envelope, with the anode of the tube directly above the centre of the object and twelve or more inches away. The film side of the negative should be uppermost. After the exposure, which may vary from a few seconds for the hand to four or five minutes for the pelvis and hip-joint, the plates are developed in the ordinary way. Hydroquinone is to be preferred to pyrogallic acid, because it produces hard negatives, and a slow development is recommended; in fact it is customary on the Continent to dilute the developer some thirty times with water, and to put the plate aside in a box for some three-quarters of an hour or more, and if the negative be still too thin to add a little normal strength developer. The satisfactory development of Röntgen ray negatives requires a great deal of care and considerable experience, and this is particularly the case in the skiagraphy of obscure bone diseases and of the thorax and abdomen.

THE RÖNTGEN RAYS IN DIAGNOSIS AND TREATMENT

The marvellous power of the Röntgen rays of penetrating our tissues, and of rendering them, so to speak, transparent, led obviously to their application in surgical and medical diagnosis; that they would have an important place in therapeutics was not until comparatively recently even suspected, and yet it is probable that they are likely to be more serviceable to mankind in the latter respect than in the former.

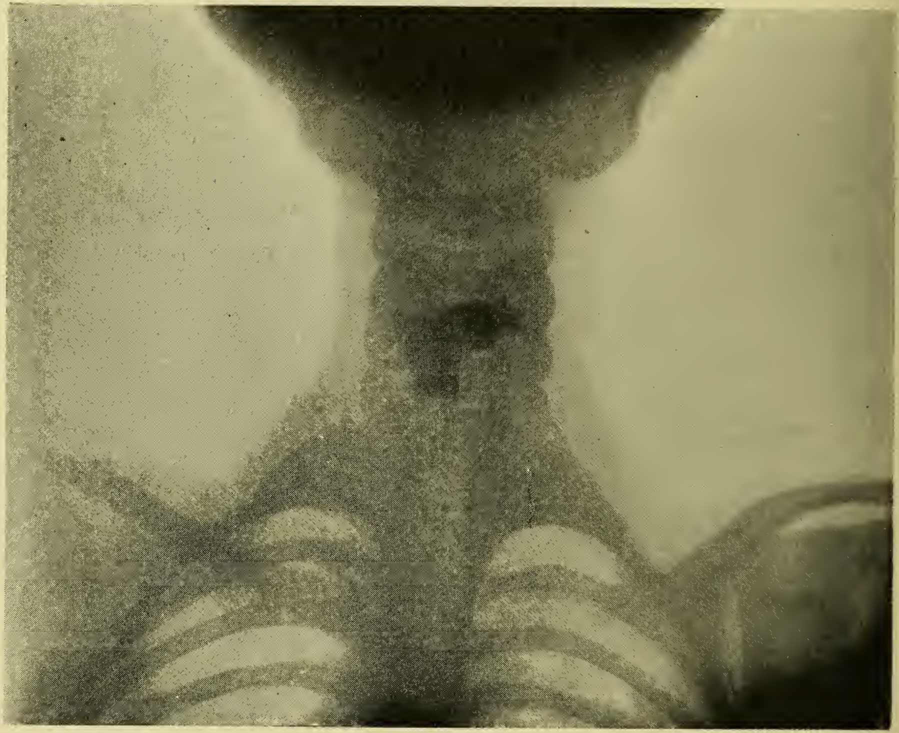

FIG. 16.—False teeth in œsophagus.

For diagnostic purposes the use of the fluorescent screen or of skiagraphy is employed.

When the screen is to be used the room should be quite dark, hence I prefer, if possible, to do screen work at night for the pupil is then also more dilated. Screens are sometimes enclosed in light-tight boxes which fit closely to the eyes, these are called cryptoscopes, and they permit of the use of the screen in broad daylight, still for difficult cases it is much better to darken the whole room.

The object to be examined should be placed between the screen and the tube and as close to the black side of the screen as possible; a little practice with the hand will soon give the operator the requisite skill, and show him how to obtain the best effect without distortion of the shadows. If the tube has a low resistance equal to about a two-inch alternative spark gap, the skin will throw a somewhat dark shadow, but if the resistance of the tube be high, the skin will be very faintly outlined, and even the bones will be transparent. For children, for the thinner parts of adults, and to bring out soft structures, a tube of low resistance should be used; for other cases a medium hard tube. By referring to the table on page 498 a good idea can be formed as to the kind of foreign body that will be visible in the tissues; thus a fragment of glass might be seen in the wrist or hand, but might be invisible in a thicker part. A small piece of lead might, however, be located in no matter how thick a part. The exact location of foreign bodies, such as a needle or a bullet, in an extremity is most easily effected by examining say the arm from two different positions at right angles to one another, and making four marks on the skin; these marks are made by holding the end of a probe in the direct line of the shadow of the foreign object, the light is then turned up and the position of the probe marked. It should be remembered also that the nearer the foreign body is to the screen the smaller and the more defined will be its shadow. For more exact localisation the author's apparatus and method may be used (Turner's *Medical Electricity*, 3rd edition, page 344), or that of Dr. Mackenzie Davidson, who has done more than any one else to make localisation precise and accurate (*Archives of the Röntgen Ray*, May 1898).

Examinations of a patient may be very rapidly made by means of the screen; the extremities and the thorax present little difficulty to a practised eye; when, however, the hip-joint or abdomen are in question it will be better to trust to photography, and in all obscure cases the screen examination should be followed by one or two photographs. The thorax should be examined both with the screen on the sternum and on the back, and the patient should be completely stripped; the ribs, vertebral column, and scapulæ will be seen, and the heart less definitely; the pulsations of the heart can be counted and the rise and fall of the diaphragm observed. Phthisical consolidations throw a denser shadow than the normal lung, and give rise to a peculiar marbling and mottled appearance. Cavities betray themselves as light areas with dark borders unless they contain pus, when they are uniformly dark. According to Dr. Hugh Walsham an earlier diagnosis of the presence of tubercle can be made by the Röntgen rays than by ordinary physical signs. Amongst other conditions which can be noticed are fibroid phthisis, emphysema, pleurisy with effusion, intrathoracic tumours, and displacement of the heart and liver. The smallness of the heart and the diminished excursion of the diaphragm in phthisis should be noted. Screen examinations are more valuable than photography in many of these cases, particularly in the differential diagnosis of aneurysm (Fig. 17), in which case a uniform pulsation may be seen, the margin of the shadow can be compared with the dull area, the patient can be examined at once both from the front and from the back and obliquely.

Photography by X-rays is a more difficult and troublesome operation. There is the question of the distance of the tube, the position of the tube and plate, and the length of the exposure; further, there is the difficulty of proper development. Nothing but practice in these procedures will give successful results. To take the case of the photography of renal calculi: it will be seen by reference to the table on page 498 that oxalates and phosphates will be most easily shown. Mr. W. H. Shenton has published in Guy's Hospital Reports an analysis of 200 of such photographs with the following results:—

Cases in which the rays and surgeon found calculi, 28.

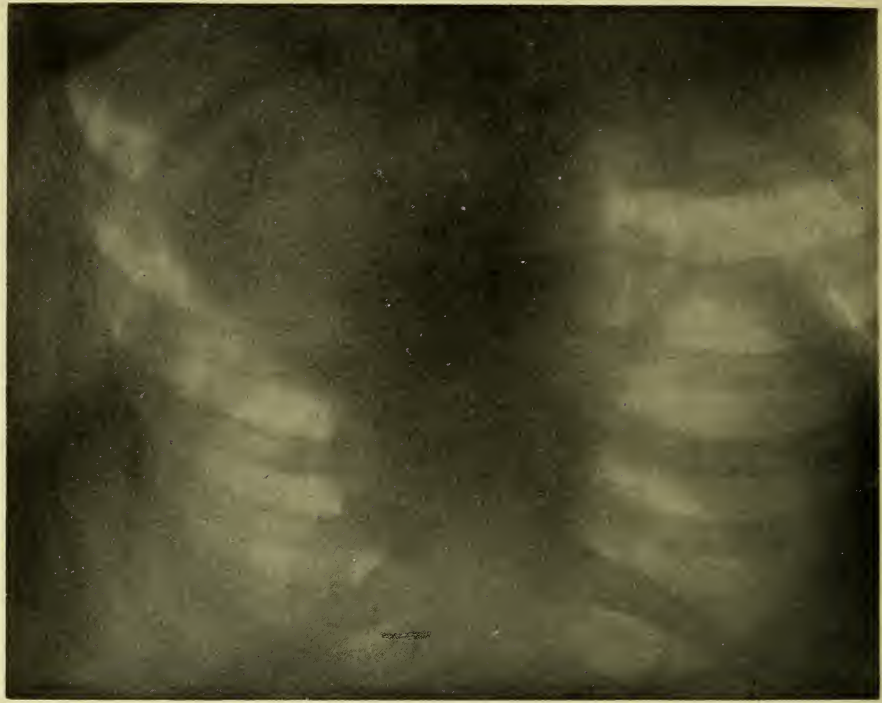

Fig. 17.—Aneurysm ascending aorta.

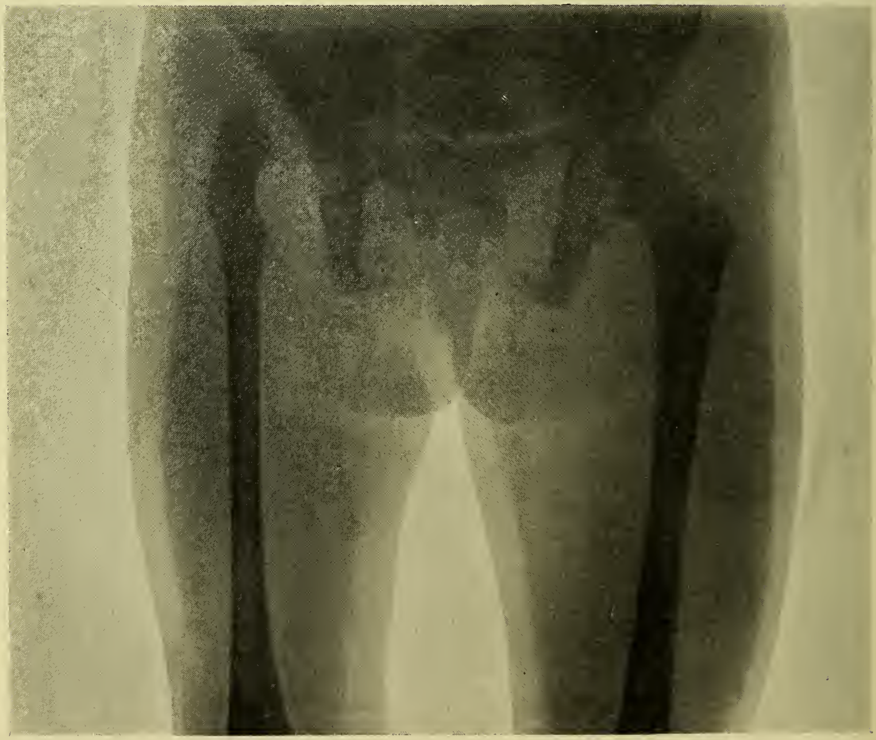

Fig. 18.—Congenital dislocation left hip joint.

Cases in which the surgeon found calculi, but the rays did not, 8.

Cases stated not to have calculi by the rays and operated on with negative results, 11.

Cases in which the rays found calculi and the surgeon did not, 2.

In 39 cases the rays were correct, and in 8 they were wrong.

Mr. Shenton's technique is to take the photograph in the prone position with the tube underneath the couch and the negative on the patient's back. A preliminary use of the screen is made, the tube is placed six inches from the abdomen, and an exposure of a minute or less is given.

The author's practice in the Edinburgh Royal Infirmary is as follows:—The patient must first be prepared by having the bowels thoroughly emptied, he is then placed in the supine position with the negative under his back, the centre of the negative should be about under the umbilicus; the respiratory movements of the abdominal contents are limited by a light flannel binder, the anode of the tube is placed over the umbilicus, and about eight inches away, and an exposure of two minutes is given. It is better, if possible, to take three negatives, and depending upon the stoutness of the patient, to give the first an exposure of one minute, the second of two, and the third of three minutes. The patient's knees should be brought up into a vertical position, and a medium or somewhat soft tube used. For the hip-joint a harder tube (for an adult) and a longer exposure of from three to five minutes are required. The negative should be supported in a case or on a flat board.

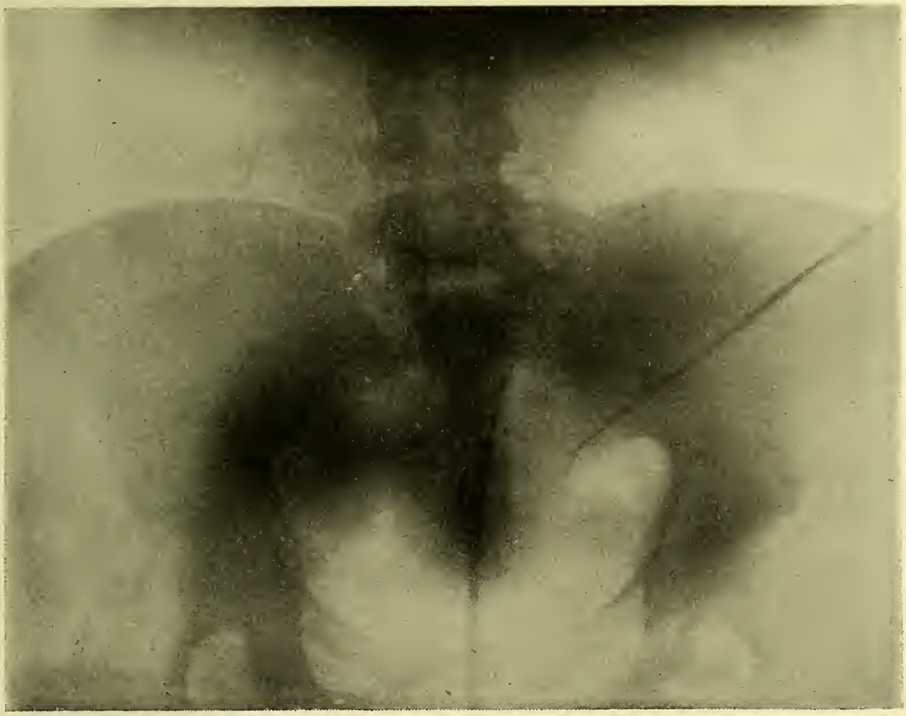

Fig. 19.—Pelvic sinus with probe.

Fluorescent screens to shorten exposures have been used, and are frequently eulogised by dealers, but are unreliable and give granular negatives with want of sharp definition. Most operators, therefore, avoid them. They are generally made of finely powdered tungstate of calcium gummed on to a flexible material; the prepared side should be placed against the film side of the negative, and both placed in the light-tight envelope together.

Curious markings in the form of wavy lines and streaks sometimes appear upon Röntgen ray negatives, and have not so far been satisfactorily explained, and this is another reason for avoiding the use of anything likely to impair the clearness of the result.

The value of the Röntgen rays in surgical affections of the bones and joints is well summed up by Dr. David Walsh in *The Röntgen Rays,* page 132. "To sum up; in dealing with bone injuries, successful radiography, compared with previous methods, offers the following advantages:—It substitutes speed, accuracy, and finality for delay and doubt; it affords exact evidence that may confirm or modify the diagnosis of the surgeon; it may furnish both grounds for prognosis and hints for treatment; it may save the patient the pain of useless, and perhaps dangerous, manipulations as well as the shock of anæsthetics; it provides a permanent record of the precise nature of an injury; it may prove a safeguard for the patient and for his medical attendant both in the present and the future; and, lastly, it can hardly fail to be of value for teaching purposes."

It may be pointed out that considerable practice is required for rightly interpreting Röntgen ray photographs, and that medical men would do well in such cases to call in the aid of an expert; more is usually to be learned from the negative than from the print, a little of the detail and contrast is lost in each transference, and in the print there is also lateral inversion; thus, if the left shoulder joint be photographed the negative will show it as the left, but the print will show it as the right. The rays are also of great value in the diagnosis of disease of the bones; in tubercular osteitis there is usually a lighter centre in the shaft due to rarefaction and a denser shadow on each side due to osteoplastic processes under the periosteum; in syphilitic osteitis the usual shadow is uniformly dense, due to a sclerosis, but in some cases of syphilis the bones are quite remarkably transparent, as in a case exhibited by the author at the Edin. Med. Chir. Society, Dec. 4, 1901. In tubercular joint disease it is common to see a general haziness and want of outline, and in advanced cases of wrist joint disease the carpal bones may be quite transparent. Cartilaginous outgrowths and callus throw very faint shadows, so do gummata and sarcomata, but if they become ossified they will be distinctly revealed.

Dislocation and deformities require no special mention. Acromegaly is a condition which exhibits characteristic changes.

Röntgen Ray Therapeutics.—The number of the diseases which have been subjected to treatment by the X-rays is a constantly increasing one; they have been used in skin diseases, rodent ulcer, malignant disease of all kinds, phthisis, pulmonary and laryngeal, trachoma, tubercular glands and joints, sinus and fistula, spinal cord diseases, and for the relief of pain.

The skin diseases in which they have been found most serviceable are:—

Lupus, eczema chronic, favus, sycosis, hypertrichosis, lupus erythematosus, mycosis fungoides, xeroderma pigmentosum, etc.

Lupus.—The Röntgen ray treatment of lupus was preceded by the Finsen light treatment. "So long ago as September 1899, Dr. Finsen had treated 350 cases of this disease with a satisfactory result in 345. This result has been so certain and constant that there is even reason to doubt the accuracy of the diagnosis of lupus vulgaris when this method of treatment appears to be ineffective. The light treatment will only cure lupus of the skin, the hard palate, the front part of the septum nasi, tongue, and the mucous membrane of the cheek" (*Brit. Med. Journal*, Sept. 30, 1899).

When the disease is more deeply situated the Röntgen rays, in consequence of their penetrative power, can be used, but the rays can also be used for the superficial cases; in fact, it would nowadays appear highly probable that the rays will supersede the Finsen light entirely in the treatment of lupus. The rays produce their effect much more quickly, and that over a much larger area; an exposure of five minutes to the rays has as much or more effect as a fifteen minute exposure to the Lortet and Genoud lamp, or an hour's exposure to the original Finsen lamp. It is, however, claimed that the cosmetic effect of the light is better than that of the rays; this is doubtful, but a more serious disadvantage of the rays is the risk there is of setting up a serious and intractable dermatitis. There are two methods of treating lupus by Röntgen rays: the one method is to expose the part to the rays alone; the other method is to combine the action of some medicament with that of the rays, this if applied in suitable cases much hastens the reaction and shortens the treatment.

If the first method be adopted a suitable mask of lead foil or of thin lead is so cut as to shade the parts that it is not desired to affect, and the patient so protected is placed about four to eight inches away from a medium or somewhat soft tube; an exposure of about five minutes is then given; this may be repeated daily for a week, and then three times a week, careful watch being kept for any signs of erythema. This usually requires about one hour's total exposure, but it may in susceptible cases and with hot tubes require less, while in other cases it may require much more. At the first sign of erythema treatment should be suspended, and the patient told to return in a week or fortnight, when the treatment will be resumed. This is at once the safest method of employing the rays, and the least painful and troublesome to the patient. The treatment in severe cases will have to be prolonged even for months, and there is a strong tendency to recurrence.

In the second method the affected part is first painted with tincture of iodine or carbolic lotion 1-20, or pure carbolic acid or Jarisch's ointment, and then protected and exposed as before. Considerable reaction follows in a day or two attended by pain, swelling, and some sloughing; the treatment is suspended, and the ulcer covered with zinc icthyol salve muslin renewed once a day. After the ulcer has healed the treatment, if necessary, can be resumed and repeated until the patient is cured. Recurrence is usual. Dr. Lowe (*Archives of the Röntgen Ray*, Feb. 1903) thinks that lupus affecting a fair skin yields more rapidly to the rays than when it affects a dark skin; the time required is increased in proportion to the amount of pigmentation. As in rodent ulcer, so in lupus, the character of the cicatrix is all that can be desired—soft, white, and yielding, with no tendency to contract and cause distortion of the face or eyelids, as so frequently happens when operative procedure is undertaken. For Röntgen ray dermatitis see page 498. Dr. Norman Walker showed a case of lupus with marked ectropion to the Edin. Med. Chir. Society in Nov. 6, 1901; under the influence of the Röntgen rays the exposed mucous membrane changed into what was, to all practical purposes, skin.

Other Skin Diseases.—In the other skin diseases enumerated above encouraging results have been recorded by various observers, but, except in favus, enough statistics have not yet been gathered to determine the proper place of this treatment.

The intractable diseases, favus, mycosis fungoides and xeroderma pigmentosum, appear to be particularly amenable to the Röntgen rays, and Dr. Allan Jamieson exhibited cases of the two latter to the Edin. Med. Chir. Society which he had apparently cured by this treatment.

Rodent Ulcer.—The treatment of rodent ulcer by the Röntgen rays is usually very successful; many such cases have now been recorded. Sometimes the action of the rays may be reinforced by a course of the Finsen light, as in the following case exhibited by the author at the Med. Chir. Society in Jan. 1902:—

Case.—A man, aged fifty-five, recommended by Prof. Annandale, was admitted to the electrical department of the Royal Infirmary on 4th December 1901. The patient had suffered for the last eight years from a rodent ulcer on the right side of the nose which had been treated unsuccessfully in many different ways. The ulcer was bean shaped and about the size of a small mussel shell, covered with brown crusts, which when removed left an irregular depression $\frac{1}{8}$ to $\frac{1}{4}$ inch in depth, with a raw greyish granular surface and shelving edges. Treatment by Röntgen rays was commenced on 4th December 1901, with exposures of five minutes daily. Slow but steady improvement followed until 10th January 1902, when the X-ray treatment was replaced by exposures of from two and a half to five minutes to the condenser spark Finsen light (see page 521) through rock salt three times a week. Three days after the first exposure marked improvement was observed, and after three exposures the ulcer had almost disappeared. After five exposures the patient returned home, the only trace of the disease that remained consisting of some slight scales towards the upper margin of what had been the ulcer (Turner's *Med. Elect.*, page 373).

This case is important because it gives an indication of what may be a more useful mode of treatment than either the Röntgen rays or Finsen light alone. The same procedure is recommended by Schiff in cases of lupus. It will be found in cases of rodent ulcer that under treatment by the X-rays the surface dries up, the advancing margin disappears, and the ulcer ultimately heals over by granulations. In many cases of rodent ulcer the pressure necessary for the treatment by Finsen light cannot be borne, and the same is true of ulcerating cases of cancer, but the X-rays can always be made use of. Cases have been recently recorded of the successful treatment of this disease by high frequency currents (see page 527). Mr. Mayon has recently contributed to the Röntgen society some remarks on the treatment of rodent ulcer of the eyelids by X-rays (*Archives of the Röntgen Ray*, January 1903); he regards the action of the X-rays as due to the inflammatory process which they set up. If a section of rodent ulcer after it has just begun to react to X-rays be examined, we find the clumps of epithelial cells which make up the growth are surrounded with enormous numbers of leucocytes. In a section of rodent ulcer which has nearly healed we find a mass of granulation tissue organising, with healthy epithelium growing in from the edges; scattered here and there among the infiltration leucocytes are epithelial cells of the growth in various stages of degeneration. The whole process is purely inflammatory, the inflammation being increased in the neighbourhood of the growth owing to the irritant action of the rodent epithelial cells. Mr. Mayon's reasons for this are—

1. These are the only histological changes found.
2. The sections showed direct invasion of the clumps of rodent cells by leucocytes.
3. The clumps degenerated from without inwards towards their centre; that is to say, the cells in contact with the leucocytes degenerate first, the innermost cells showing no change at that time.

In treating a rodent ulcer, Mr. Mayon removes portions of the growth from time to time to see if there are any active cells of the growth present, and when they have all disappeared to cease the treatment.

Cancer and Sarcoma.—It may be claimed that the X-rays now have a definite place in the treatment of malignant disease, and that is in inoperable external cases, but evidence is accumulating that they may also be found of value in internal cases. The clinical results of the treatment are:—

1. To remove or diminish the pain.
2. To loosen adhesions and to cause the disappearance of the contracting and tightening sensation of scirrhus.
3. To cause an ulcerating and sloughing surface to take on a healthy and healing aspect, and to diminish in size through the growth of epithelium from the edges, and even, as in two cases of the author's, to become completely covered with healthy skin.
4. To dissipate and remove cancerous and sarcomatous tumours.

Twenty-five cases have been under the writer's care, and of these fifteen affected the mamma; two affected the tongue; two affected the scalp; one affected the penis and scrotum; one affected the cervix uteri; one affected the rectum; one affected the larynx; one affected the glands of the groin; one affected the side of the neck.

Nearly all these were for various reasons inoperable cases, the derelicts of surgery, and therefore all the more difficult to treat successfully, and yet all but three of them showed improvement, and some of them remarkable improvement. The breast cases were the most successful, and the tongue the least. The following is an interesting case:—Inoperable ulcerating scirrhus of four years' duration of the left mamma in a woman aged forty-nine, with enlargement of the axillary glands. The ulcer was obliquely placed, and measured 3½ inches by 3 inches; the patient complained of pain, stiffness of the left arm, and insomnia. An exposure of five minutes to the X-rays was given every third day. After five applications the pain and insomnia had gone, and the patient felt better and stronger; the ulcer appeared to be shallower, but was still partly covered with a greenish slough. Rapid improvement continued, and after twenty-two exposures the ulcer was entirely covered with a thin vascular skin. Treatment was now suspended. Three months later the patient was in the same condition, but the skin appeared to be a little thicker.

Another case was very similar, a large ulcerating surface completely skinning over after nineteen applications, and continuing to improve after the cessation of the treatment.

In a case of Dr. Ritchie's of large sarcoma of the side of the neck, recommended to the author for treatment, seventeen exposures were followed by the complete disappearance of the external tumour; the growth, however, continued internally, and dermatitis interfered with the exposures, and the patient died.

The difficulties of satisfactorily introducing the X-rays into the rectum and vagina have led the author to prefer the use of high frequency currents for such cases; in fact, there is a strong tendency now to substitute the latter for all cases of malignant disease, whether internal or external.

Dr. W. B. Coley has published an important paper on the treatment of sarcoma by the Röntgen rays, and discusses the following conclusions amongst others:—

1. That the results in the cases thus far treated prove that the Röntgen rays have a remarkable inhibitory action upon the growth of all forms of malignant disease, and this is especially true of sarcoma.

2. That this action, in many cases of even far advanced and inoperable malignant disease, may result in the total disappearance of the tumours, often without any breaking down of the tissues, the new growths being apparently absorbed.

The Röntgen rays have a very marked influence upon the pain and nearly all types of malignant tumours, causing in many cases entire relief.

Dr. Clarence Skinner, *Journal of Advanced Therapeutics*, New York, October 1902, describes thirty-three cases, including carcinoma of the uterus (eight cases), carcinoma of the breast (eight cases), and others of epithelioma and osteo-sarcoma. The clinical data are summarized as follows: complete disappearance of the malignant process has apparently been secured in three cases; permanent reduction of the tumour in thirteen; temporary reduction with subsequent increase in one; permanent arrest of growth in two. There was no effect positively demonstrated upon the size of the lesions in fourteen. Complete permanent relief of pain in fourteen cases, complete temporary relief in two, partial relief in eight, no relief whatever in four, and in five there had been no pain.

The author is inclined to recommend that the exposures should not follow one another too rapidly; his best results have been obtained with two or even with one seven-minute exposure a week; further, the treatment should be interrupted from time to time, for the patient will continue to improve, the therapeutic effect of the ray being like its effect in producing dermatitis cumulative. The very greatest care should be taken in malignant cases to avoid setting up a dermatitis.

Phthisis; Tubercular Glands; Sinus.—The Röntgen rays have been tried in cases of phthisis pulmonalis and laryngea by a few observers. Ten cases have been under the author's treatment; four improved, the others were unaffected. Dr. P. R. Turnure, *New York Medical Record*, 7th February 1903, treated two cases of tuberculosis of the larynx, one for four and the other for six weeks without improvement.

The results are more favourable in tubercular glands and joints. A large number of the former have been under treatment by the Röntgen rays in the electrical department of the Edinburgh Royal Infirmary, and in most cases with beneficial results; it is, in fact, rare to meet with a case which does not improve. Good may also be anticipated in the case of tubercular joints. The following case of Professor Annandale's will illustrate this:—Case: patient aged twenty-seven, suffering from tubercular disease of the right elbow. The elbow became swollen and very painful after a fall. As it did not improve under rest Professor Annandale excised it. The wound has never healed properly, and there is still pain and considerable swelling. After a month's exposure to X-rays three times a week of five minutes' duration there was decided improvement, the movements at the elbow were fairly good, there was practically no pain, and little discharge. Professor Annandale expressed himself as greatly pleased with the result.

Sometimes chronic ulcers and sinus improve under X-ray exposures; the vascular changes, leucocytosis, and growth of connective tissue produced by the rays are likely to be beneficial. Sjogren and Sederholm (*Archives of the Röntgen Ray*, August 1901), report four cases in which the cause of ulceration was uncertain; the only point in common between them was that they had resisted other methods. Two of these were cured, and one greatly benefited. Dr. Berry Hart, *British Medical Journal*, 31st May 1902, describes two cases treated in the electrical department of the Edinburgh Royal Infirmary, in which obstinate callous sinuses in the abdominal wall healed up—one after a single application of the X-rays for photographic purposes with a probe in the sinus, the other after three exposures (Fig. 19). The author has observed similar good results in some cases, but in others, particularly in fistulæ, no beneficial effects. High frequency currents are likely to be of more service in such cases.

Trachoma.—Mr. M. S. Mayon and Dr. David Walsh have reported cases of trachoma cured by exposure to the Röntgen rays. Mr. Mayon (*Archives of the Röntgen Ray*, January 1903) states that the final result to the lid is most satisfactory. Instead of the white, puckered conjunctiva gained by other methods, a supple, non-contracted, non-scarred conjunctiva, with no obliteration of the fornices, unless they are already gone before treatment, is produced, similar to the soft, supple scar in the skin following by this form of treatment in rodent ulcers, as compared with the dense cicatrix of excision.

As regards the effect on the pannus, it often clears with great rapidity, especially if recent, and it is the common thing for patients to say that they see more clearly from almost the first exposure. But even dense corneal opacity will often clear considerably, and in one case of extensive destruction a cicatrization of the cornea, in which at the commencement of treatment the patient could only see shadows, in two months she could count fingers three feet away.

The chief advantages of this treatment are:—

1. It leaves considerably less deformity.
2. It is a painless treatment.
3. The pannus clears more thoroughly.

Diseases of the Spinal Cord.—Dr. Byrom Bramwell has had some nervous cases, mostly suffering from locomotor ataxy, treated with the Röntgen rays to the lumbar and lower dorsal region, in the electrical department of the Edinburgh Royal Infirmary. He exhibited one patient to the Edin. Med. Chir. Society; this patient had derived marked benefit from the treatment and had put on weight. The writer tried the rays in an old case of myelitis without effect.

Neuralgia.—The Röntgen rays may be tried for this; they will nearly always relieve the pain of cancer, and the author has seen cases of sciatica and even of toothache relieved. This relief of pain was strikingly brought home to me in a case of severe and intractable toothache sent to me for diagnostic purposes by Mr. Watson, L.D.S. Several photographs of the suspected teeth (exposures from two to ten seconds) were taken, but when the patient returned in a few days' time he told me that his persistent pain had disappeared shortly after the exposures. Stembo (*Archives of the Röntgen Rays*, January 1901) narrates cases of neuralgia which were relieved as a rule after the third application.

THE FINSEN LIGHT AND HIGH FREQUENCY CURRENTS

By consulting the table on page 497 it will be seen that the Finsen light consists chiefly of the blue, indigo, violet, and ultra violet rays of the spectrum. Such rays are given off by the sun and by certain artificial lights, such as the arc light and that of a condenser spark, particularly in the two latter cases if iron poles or electrodes be used. The original large arc light used by Prof. Finsen has been superseded in this country by small arc lights placed close to the patient and separated from the diseased area by two diaphragms of quartz and a layer of running water. This arrangement is necessary to cool the light by absorbing the radiant heat rays. A type of such a lamp is the Lortet-Genoud or its London hospital

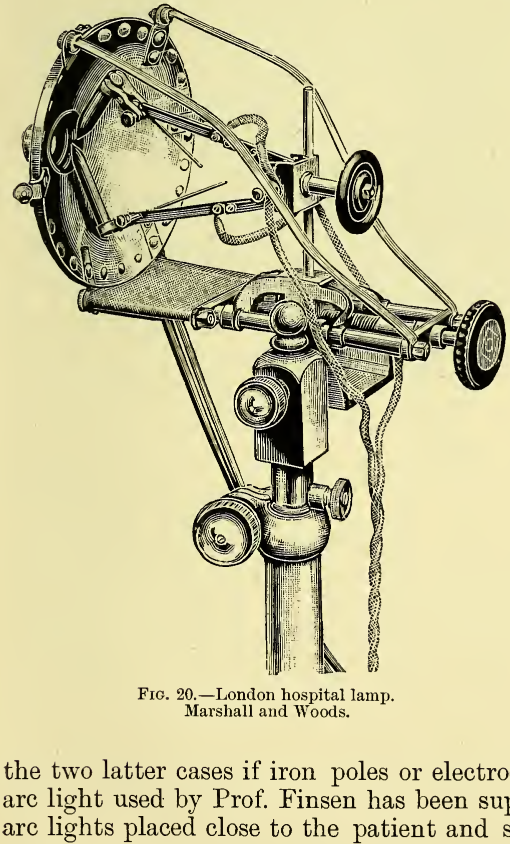
FIG. 20.—London hospital lamp. Marshall and Woods.

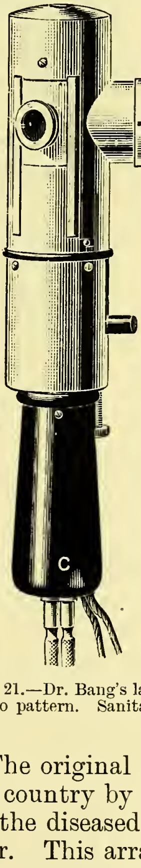

FIG. 21.—Dr. Bang's lamp. Dermo pattern. Sanitas Co.

modification (Fig. 20). To render the part to be treated anæmic the patient presses it against the outer quartz diaphragm, and the part is thus brought within 2 or 3 inches of the light. To supply the lamp with electricity it must be attached to the electric light mains with a sufficient resistance in series to bring the current down to about seven to ten ampères. A number of these lamps have now been in operation in the United Kingdom for some time, and it is found that an exposure of some ten to twenty minutes is sufficient to produce the necessary reaction. With the original Finsen large arc light the exposures lasted an hour or more, and the area affected was one-quarter the size.

More recent arc lights use iron poles (Dr. Bang's lamp) Fig. 21, or carbon poles with cores of iron dust (Dr. Strubel's lamp) Fig. 22. The advantage of using iron is that its spectrum is richer in ultra violet rays. Dr. Strubel's lamp possesses the further advantage of requiring less resistance in the circuit and of giving double the light; it consists of two small arc lights placed compactly together; as each light requires about 45 volts' pressure, the two will require 90 volts so that they can be run on a 100-volt circuit with but little added resistance. The *British Medical Jour.*, 4th Jan. 1902, quoting a German authority, states " that Dr. Bang's lamp need not be larger than an ordinary tablespoon, compressing and supporting apparatus included, and that its cost would be about £3. While the light from an ordinary arc lamp can kill cultures of the staphylococcus pyogenes aureus in 4½ minutes, the light of Dr. Bang's lamp, under similar conditions, can kill them in less than four seconds, thus giving a bactericidal power sixty times stronger than that of the ordinary arc lamp. With his apparatus in both healthy and lupoid skins a marked light erythema of many days' duration

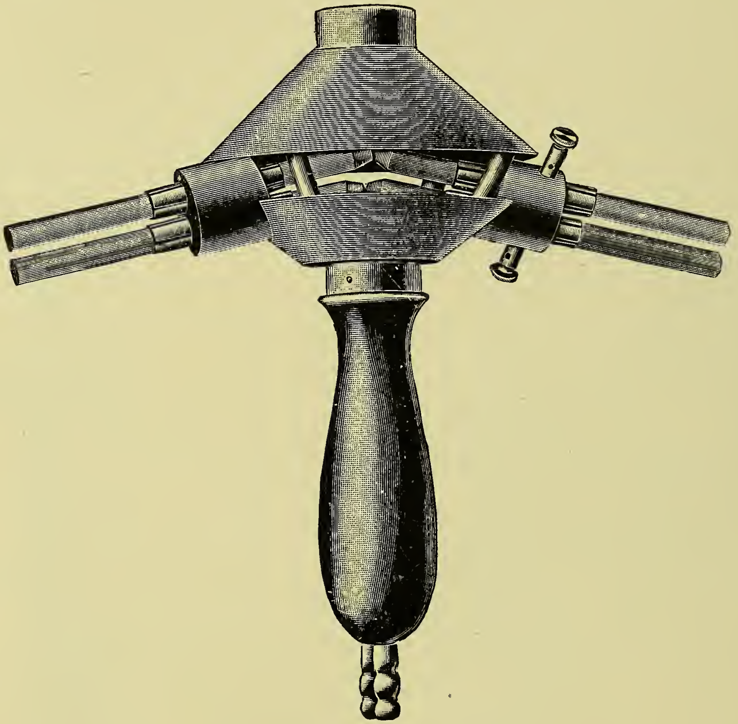

Fig. 22.—Dr. Strubel's lamp. Schall.

may be produced with five ampères of current over an area 4 inches square in five or even in three minutes, and as strong as that hitherto obtainable with sixty ampères of current (original Finsen light) in seventy-five minutes."

The disadvantage of all the arc light sources of the Finsen rays is that their sources radiate not only the Finsen rays, but the whole of the rest of the spectrum as well, including the infra red or radiant heat rays, and for this reason the light has to be cooled by running water, and the water and quartz windows absorb an appreciable quantity of the active Finsen rays, and their interposition also prevents the diseased area from being brought quite close to the light. What is required is a cold source of light which radiates only the blue violet and ultra violet rays, and the light of a condenser spark more nearly answers this purpose. This spark is obtained by joining the outer and inner coatings of a condenser to the secondary terminals of a large induction coil, and causing the condenser to discharge between two iron electrodes. This lamp—introduced by Prof. Görl (Fig. 23)—can be obtained from Schall, 55 Wigmore Street, or from Leslie Miller, 93 Hatton Garden, E.C. The lamp is contained in a metal case, and its open end is closed with a diaphragm of rock salt, ice, or quartz which is pressed against the affected area. The author's experiments on the transparency and opacity of bodies to ultra violet light showed that pure polished rock salt was more transparent than either quartz or ice (Turner's *Medical Electricity*, 3rd edition, page 366). Glass, mica, ebonite, and gelatine are opaque; the opacity of glass is to be particularly noted; ultra violet rays may be present in abundance inside a Röntgen ray tube, but they will all be stopped by the glass. Rock salt is twice as transparent as ice, and from twenty to thirty times as transparent as quartz. The rock salt should be cut into the form of a convex lens and should be polished. It must be kept quite dry; a film of moisture upon it destroys both its

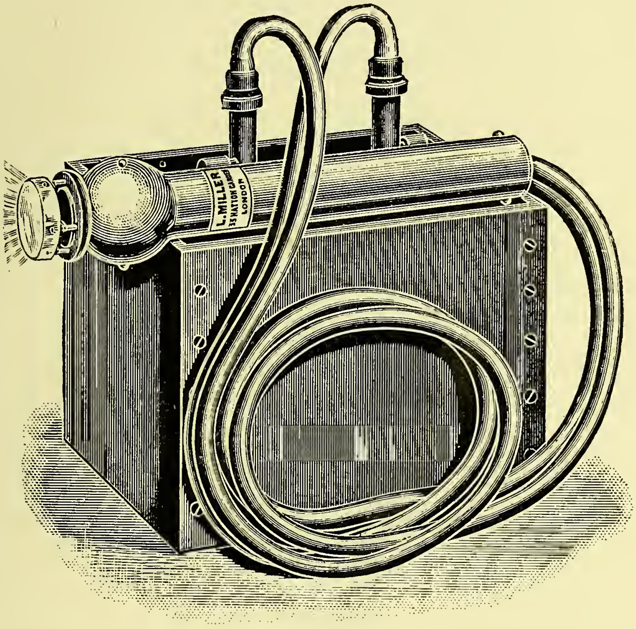

FIG. 23.—Condenser spark lamp. Turner's *Med. Electricity.*

transparency and its polish. It may be cleaned with absolute alcohol and polished with chamois leather.

An objection to the use of this lamp is the crackling noise of the spark discharges; it is also said that its action is more superficial than that of the arc light; despite of that we have reduced the exposure with this lamp to from two and a half to five minutes in the electrical department of the Royal Infirmary, Edinburgh.

The Finsen light has been used chiefly in the treatment of lupus (see page 514); that it is a specific for superficial cases of lupus vulgaris there can be no longer any doubt, hundreds of such cases are on record. The disadvantage is the great length of time required in the treatment, and the smallness of the area exposed at one time. In consequence of these drawbacks there is a strong tendency to treat cases of lupus with the Röntgen rays instead of with the Finsen light (see page 515), the area treated is much larger, and the time required and the expense less. To the employment of the Röntgen rays there is, however, attached the risk of a dermatitis, while such a sequela is not to be feared with the use of the light.

Care must be taken in treating cases with the Finsen light to see that the pressure upon the diseased area is sufficient to express the blood; the use of ice as a compressing medium has the advantage of aiding the expression of blood by its chilling effect. The length of the exposure will be governed by the particular lamp selected, but it should be sufficient to produce a reaction of slight erythema with some smarting and tingling.

The cases of lupus for which the light is particularly suitable are those in which the patches are small and well defined, and in positions such as over bony prominences where the necessary pressure can be exerted. As a result of repeated exposures the granulomatous tissue of lupus has its vitality destroyed and undergoes degeneration; any bacilli present are killed. The writer has treated cases in which there was a lupus patch on each side of the face, the one side with the Röntgen rays, and the other side with the Finsen light, and he has always found that the improvement was more rapid and general on the side treated by the rays. The following is a case in which the light treatment had a very rapid effect. Case—Lupus of four years' duration affecting the right ala of the nose, and consisting of a small punched out patch about a quarter of an inch in depth; eleven exposures of two and a half minutes each to a large condenser spark lamp with a rock-salt compresser sufficed to bring about a cure. To assist in the production of a reaction applications of pyrogallol, acid nitrate of mercury, or iodine may be tried.

In the case of lupus erythematosus the Finsen light appears to be often of more service than the Röntgen rays. In a case of well-marked lupus erythematosus of two years' duration which failed to yield to X-ray treatment, the writer has observed distinct improvement follow the application of the Finsen light.

When the necessary pressure can be borne the light can also be used for rodent ulcer, and Dr. Finsen of Copenhagen had many successes with this treatment. The light is also of service in the treatment of superficial cancerous nodules. In a case of Mr. Cotterill's of multiple scirrhus (exhibited at the Edinburgh Medico-Chirurgical Society, 7th May 1902) ultra violet light was employed by the author with excellent effect to the cancerous nodules, which rapidly disappeared under its use.

High Frequency Currents

Though these currents have been known for about a dozen years under the name of Tesla or d'Arsonval, they have only recently become prominent in practical medicine. Introduced first by Tesla and Elihu Thomson, they owe to d'Arsonval their physiological and therapeutical importance. These currents differ principally from those developed by an alternating current dynamo or an induction coil in the fact that the electromotive force or pressure is exceedingly high, and the alterations or reversals (frequency) inconceivably rapid. A good induction coil may develop an electromotive force or difference of potential of 50,000 or more volts, and if provided with a Wehnelt break the number of its interruptions may reach 1000 per second, but the electromotive force of the high frequency currents may reach a million or more volts, and the frequency may attain many millions per second. This frequency is occasioned by the oscillating character of the discharge of the Leyden jars; the jar is first charged by the induction coil or static machine, and when the potential has been sufficiently raised it discharges across the spark gap, and this discharge is of an oscillatory nature. Rushes or surgings of current occur first in one direction and then in another with a frequency of alternation quite unapproachable by any mechanical means.

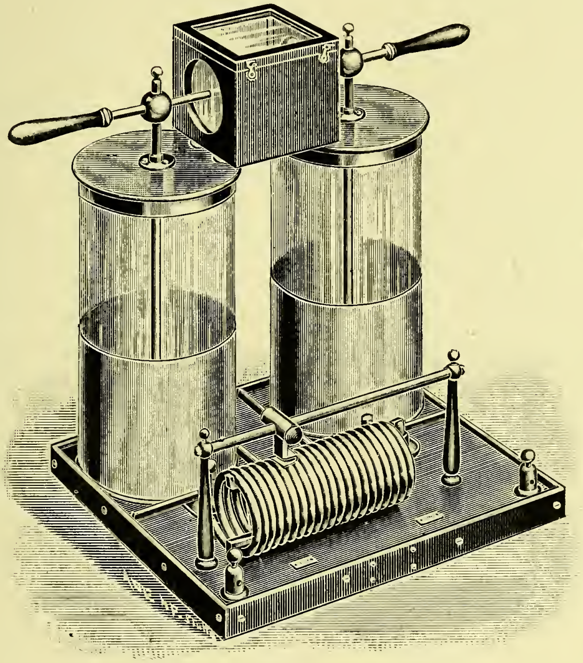

FIG. 24.—High frequency apparatus. Schall.

Mode of Production of the High Frequency Currents

An induction coil or a static machine may be used for charging the two Leyden jars; the former is the best and most reliable arrangement, the output from the latter, unless very large and very rapidly rotated (see Gaiffe's machine, p. 499), being insufficient to keep the jars fully charged. The two inner coatings of the Leyden jars (Fig. 24) are connected to the secondary terminals of the induction coil, and the spark discharge may be allowed to occur either between two especially supplied balls enclosed in a box to deaden the noise and shade the light, or between two balls attached to the ordinary spark electrodes of the coil.

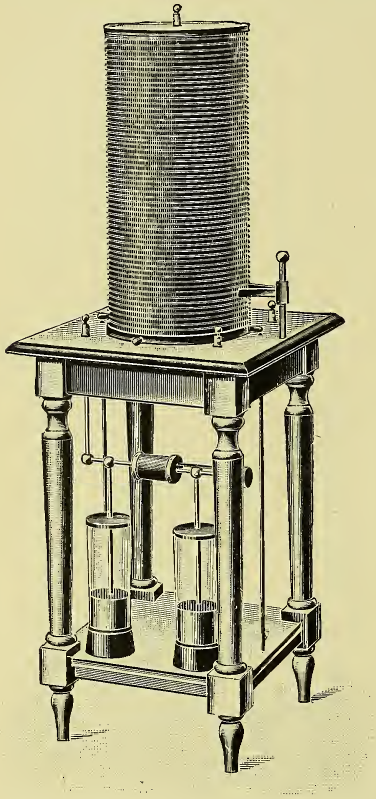

FIG. 25.—High frequency apparatus. Schall.

The outer coatings of the jars are attached one to each end of a solenoid of thick copper wire.

This is all the apparatus that is absolutely necessary, but the effects will be very much improved if the resonator of Oudin be added. Dr. Oudin's resonator (Fig. 25) consists of some two hundred feet of copper wire wound round a large framework of insulating material. When a proper length of the wire of the resonator is placed in parallel with the solenoid, the former, to use an analogy, acts the part of the sounding board of a musical instrument, and vibrates in unison with the solenoid so as to greatly reinforce the electromotive force. When the two are in proper accord, the upper turns and the terminal of the resonator will give off a very powerful violet coloured effluve (best seen in the dark). The resonator should be provided with a sliding contact to which the wire from one end of the solenoid can be attached, and this contact should be moved up and down until the best effects are produced; to obtain a more exact adjustment the resonator should be capable of rotation. In some instruments the solenoid is suppressed altogether, and the lower turns of the resonator take its place. Before the invention of the resonator the usual method adopted for producing high frequency currents was to allow the Leyden jars to discharge through the primary of an oil induction coil (see Turner's *Medical Electricity*, p. 144); d'Arsonval has quite recently reintroduced this method in his bipolar induction coil, but which uses air instead of oil as the circulating medium. This is a bulky instrument, consisting of a cylinder on which the secondary wire is wound, and round it, but separated from it by a layer of air, are a few turns of a thick primary wire supported by insulating legs; the latter is arranged to slide along and parallel to the axis of the secondary wire. This apparatus is supplied by Gaiffe. The one pole of the secondary wire is attached to the electrode for the patient, the other to earth or also to the patient. Dr. Macintyre has introduced a special device for reversing the current as it comes from the condensers, so as to make the arrangement more suitable for use with a static machine. Dr. Oudin *Annales d'électrobiologie*, July-August 1900) makes the following remarks as regards d'Arsonval's bipolar coil:—"When we wish to administer general high frequency treatment to a patient, I do not think that we must attach much importance to this *bipolar* character, which must perforce exist when the efflux from one end of a single resonator is directed upon an individual.

For at every instant when a positive influx passes to such a capacity as the body of a patient, the capacity has induced upon it a negative potential, and *vice versa*. But I think that in making local applications we get a zone of greater density when a bipolar coil or resonator is used."

There are three chief methods of applying the high frequency currents for purposes of treatment:—

1. " Autoconduction."
2. Condensation.
3. Direct local applications, either by *a*, the effluve; or *b*, intercalation of the patient in the circuit by the direct contact of suitable electrodes.

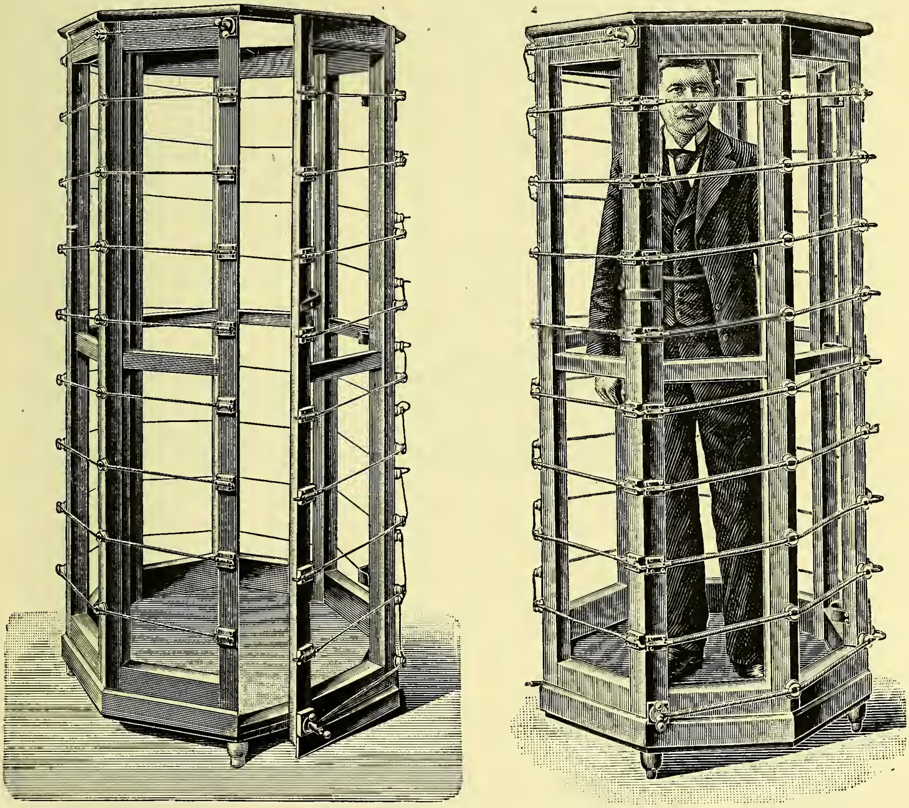

FIG. 26.—Autoconduction. Schall.

1. In "autoconduction" the solenoid is made (Fig. 26) large enough to enclose the patient without touching him, and the patient is placed inside; he may either stand or recline according to the direction of the long axis of the solenoid, which may be vertical or horizontal, and arranged round a couch. The patient forms the secondary of a gigantic induction coil and will be the seat of induced currents.

2. In "condensation" the patient forms one of the plates of a condenser or Leyden jar; for this purpose a couch is provided, the back and lower part of which is lined with metal, and carrying a terminal by which it may be attached to the resonator or to one end of the solenoid. Over the metal is placed an insulating material such as felt, and over that the ordinary cushions. The patient reclining on the couch is connected to earth or to the other end of the solenoid by grasping an electrode attached

to a chain; the other end of the chain may pass to a gas or water pipe, or to the solenoid, or to both.

The felt and cushions form the dielectric, and the patient the outer or earthed coating of the condenser. At every electrical oscillation the patient will become charged and discharged, and the charges will vary in sign.

3. The "Effluve." A pointed conductor attached to the resonator is approached to the patient; the conductor must be held in an insulating handle. As the point approaches a violet "effluve," starting from both the point and the patient, will complete the circuit. The form of this "effluve" resembles that of the lines of force between two opposite magnetic poles. If the point be brought too near sparks will pass, and these are unpleasant to the patient. A variety of this method (Fig. 27) is to enclose the pointed conductor in an insulator such as ebonite or glass (condensing electrodes); such an electrode may be brought into actual contact with the skin, and used either in a labile or stabile method; it will cause slight burning and tingling sensations. Or a vacuum tube or a tube containing acidulated water may be attached to the resonator and used as an electrode; by these electrodes the strength of the applications is diminished.

Lastly, the patient may be directly intercalated in the circuit by the firm application of two large surfaced electrodes attached respectively either to the two ends of the solenoid (in parallel), or one to the solenoid and one to the resonator.

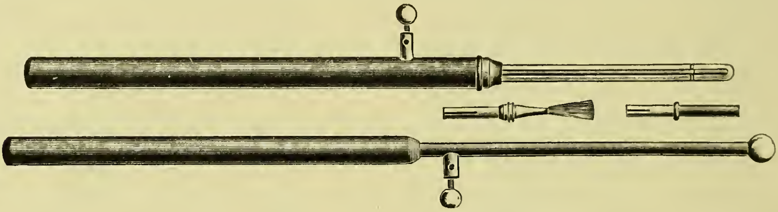

Fig. 27.—High frequency electrodes. Schall.

With the exception of the effluve none of these methods cause the patient any appreciable sensation. The former occasions slight smarting, tingling, and burning, and it is followed by a vivid hyperæmia, which may take from some hours to two or three days to disappear. The strength of the applications can be graduated in various ways, thus:—

a. The primary current supplying the induction coil can be altered in strength or voltage.

b. The sparking distance can be increased or diminished; the greater the length of the spark the more powerful are the oscillations.

c. The resonator may be more or less accurately tuned to the solenoid, etc.

The physiological effects of the high frequency currents have been investigated by d'Arsonval, Oudin, Bruchard, and others.

Except in the case of the "effluve" and of spark discharges, no sensation is experienced and no stimulation of muscle occurs, even though a current of three ampères be traversing the body (*Les courants de haute fréquence*, Denoyés, p. 64). M. Cornu allowed electrical energy at the rate of nearly one-horse power to pass through his body without experiencing any sensation whatever; six incandescent electric lamps (125 volts 0·8 ampère) were illuminated by the current. The most probable explanation of this immunity is that of d'Arsonval, who (Turner's *Medical Electricity*, p. 187) suggests that the tissues cannot respond to such rapid alternations. The retina, for instance, only responds to about one octave of ethereal vibrations—those that lie between 497 (red) and of 640 (violet) billions per second; all others, the dark heat rays and the ultra violet actinic rays, are without effect upon it. So too with the auditory nerve, which has a range from seven to eight octaves. D'Arsonval, using alternating currents for stimulating muscles by their motor nerves, found that if the alternations exceeded some 5000 a second, the effect produced steadily diminished as the frequency rose.

It has, however, been established by various authorities—d'Arsonval, Denoyés, etc.—that certain modifications in nutrition are brought about. Denoyés (*Courants de haute fréquence*, p. 103) states "that the influence in nutrition is shown, as regards the circulatory system, by vascular dilatation and lowering of the arterial pressure, afterwards followed by a continued elevation; as regards the respiratory system by a greater elimination of carbon dioxide and a more active absorption of oxygen by the blood; as regards the urinary secretion by a notable increase in the elimination of waste products; and, lastly, as concerns the heat-regulating mechanism by an increased production of heat." In addition to the vascular dilatation and hyperæmia a degree of anæsthesia is produced by local applications.

The high frequency currents can affect certain toxines; thus d'Arsonval found that the diphtheria toxine suffered an attenuation, and Bonome rendered the streptococcus toxine ten times less virulent. The effect of the current is to convert the toxins into toxoids. Since toxoids are not only capable of producing immunity, but are also very much less poisonous, there may be hope for the clinical treatment of diphtheria and tetanus by the conversion of toxin into toxoid within the living body (A. S. Grunbaum, "Goulstonian Lectures," *B.M.J.*, March 21, 1903).

Therapeutic Applications

The currents have already been applied over a wide field of disease, and a considerable time must elapse before their proper rôle in treatment can be appreciated. The following are some of the diseases for which they have been used:—

Gout, rheumatism, diabetes, obesity, tuberculosis.
Affections of the stomach, dilatation, hæmorrhoids, and fissure.
Progressive muscular atrophy, neuritis, spinal diseases.
Trachoma, tinnitus.
Malignant disease.
Skin diseases.

It is impossible in the space of this article to do more than to refer to one or two of the diseases in which there is the greatest consensus of opinion as to the beneficial effect of the treatment; for details as to the other diseases the following works and journals may be consulted—*Courants de haute fréquence*, Denoyés; *High Frequency Treatment*, Chisholm Williams; various papers in the *Archives de physiologie*, by d'Arsonval; *Compte rendu de l'Académie des Sciences* (Dec. 30, 1901), by Bordier; papers by Apostoli and Berlioz, and Laquerrière in the *Archives d'électricité Médicale* and the *Annales d'électro biologie*, etc., etc.

A good deal both of experimental and of clinical work has been done in "tuberculosis." Denoyés inoculated a number of guinea-pigs with tubercle and studied the action of the various modes of employment of these currents upon them; other guinea-pigs inoculated at the same time served as controls. The net result of these experiments, which are narrated with great care and elaboration in Denoyés' book, serve to show that the high frequency currents, particularly under the form of a moderate effluve, have a beneficial effect upon experimental tuberculosis. Rivière states (*B. M. J.*, Jan. 11, 1902), "High frequency currents exercise a certain curative action upon tuberculosis. The microbe cannot resist the repeated application of these currents; its reproductive power and the virulence of its toxins becomes attenuated, a fact which had already been proved by the laboratory experiments of d'Arsonval. It appears that at the same time the human organism under the influence of these currents gets stronger, its enemy, the microbe, grows weaker. The acceleration that these currents bring to the circulation of the blood and lymph favour osmotic action. This allows the organism to eliminate the refuse and the toxins that invade and infect it. It is also probable that under the influence of this form of electrisation the beneficial action of the phagocytes increases in activity. It thus appears evident that in these conditions the attacked organism recovers its strength, and, aided by the phagocytes, finally prevails against the bacillus. It is therefore sufficient to place the patient in the best conditions of food and hygiene to avoid the return of the disease."

Doumer, Oudin, Rivière, Denoyés, and others have recorded many cases of chronic pulmonary consumption which derived great benefit from the application of the effluve to the affected apices. Chisholm Williams records forty-three cases, of which forty-two put on weight, and lost all symptoms except in a few where a slight cough and a few bacilli may be found occasionally.

Where there is any grave affection of the heart the currents should be used with caution. Good results have been obtained in "chronic dyspepsia" and in "dilatation of the stomach," but the most striking results have been achieved in "hæmorrhoids and in fissure." Dr. Walker mentions an acute case which was apparently cured by two applications; another case of long standing with bunches of piles protruding, bleeding frequently and painful anal fissure has, after daily applications for four weeks, shown almost complete recovery. Doumer records permanent cure in nine cases, each one of which was associated with a fissure. Five or six local applications were sufficient to cure the bulk of his series. The author, using a condenser electrode, can quite confirm these results; one application is usually followed by marked relief. There can be no doubt about the great value of this treatment in hæmorrhoids. The application, lasting from five to ten minutes, should be made by a rectal condenser electrode brought into actual contact with the sphincter and gradually passed into the rectum; owing to the analgesic action of the current but little discomfort will be felt.

Denoyés publishes a case of "progressive muscular atrophy" in which he obtained a remarkable result (*Courants de haute fréquence*, page 289); similar cases are also on record; secondary muscular atrophies are also benefited.

Condensations or local applications may be tried in "tabes dorsalis." A case treated by the author in this way undoubtedly benefited. In "trachoma" Dr. Walsh found "that twenty-three painless applications of the effluve caused the disappearance of a disease that under ordinary treatment would have lingered on for two or three years. The only altered conditions of environment was the application of the effluve, and the patient's other eye remains as bad as ever, so that the brush discharge may reasonably be regarded as the curative agency" (*Archives of the Röntgen Ray*, Jan. 1903).

The effluve has been used with varying degrees of success in eczema, psoriasis, pruritus, rodent ulcer, and lupus.

Four cases of "diabetes" have been recorded by Vietti, and two by d'Arsonval, in which the sugar either disappeared or was much reduced; others have found that though the general condition was benefited, no diminution in the glycosuria followed. Auto-conduction is the method usually applied in diabetes.

More recently these currents have been found of distinct value in certain cases of "malignant disease," such as cancer of the bladder, uterus, rectum, throat, and nasal cavities. It is possible that they may partly supplant the Röntgen rays in the treatment of malignant disease, for they can be used not only for the cavities above mentioned, in which much success with the Röntgen rays can scarcely be expected owing to the tissue which has to be penetrated, but also for the external cases; and they have this great advantage over the rays, namely, that they do not produce a dermatitis. In properly selected cases the author has seen the disappearance of pain and of pressure symptoms, the complete healing of ulcers, the diminution or disappearance of the growth, the restoration of sleep and appetite, and the gaining in weight, but in no case yet has he observed a complete cure. A very instructive case was the following:—

The patient had been previously operated on, and the right mamma and pectoralis muscle removed for a scirrhus of a very malignant type; owing to a rapid recurrence both in the scar and to the appearance of two lumps in the left mamma, accompanied by many skin nodules and the enlargement of the superficial and deep lymphatics, the electrical treatment was tried. After consultation with a surgeon it was decided to treat the right side with the Röntgen rays and the left side with the effluve on alternate days. The rays had to be given up after twelve five-minute applications owing to a commencing dermatitis; the high frequency treatment on the left side could be continued. On a re-examination in consultation with the surgeon, after a total of twenty-five applications—twelve of the rays and thirteen of the effluve—both sides showed much improvement, the superficial nodules had disappeared, the lymphatics were smaller, the right arm less swollen and more movable, the lumps in the left mamma were more diffuse and smaller, and it appeared to us that both methods of treatment had been of equal efficiency. All treatment had, however, to be suspended owing to internal secondary growths causing œdema of the lower extremities. In a case of Dr. Macmillan's of recurrent epithelioma after removal of the cervix, the Röntgen rays, which had been used with benefit in the electrical department of the Edinburgh Royal Infirmary, had to be given up owing to a dermatitis; this case being now treated by a condenser vaginal electrode with the effluve, showed the same temporary improvement which had attended the use of the rays, each application being followed by a lessening in the amount and odour of the discharge, and by a feeling of *bien-être.* Two applications of seven minutes each a week seemed to be sufficient to keep the disease in check.

Where possible the author prefers to treat such cases by the effluve locally on one day and by condensation on the following day, so as to obtain both a local destructive effect on the growth and a general nutritional improvement. In the *West London Medical Journal* for July 1902, Dr. James Allan records four cases treated by the effluve. The following are brief notes of these cases:—

Case I.—Miss H., aged 48, operated on for sarcoma of the antrum twice. On a further recurrence electric treatment was begun. The growth was easily seen in the nasal passages; the patient looked very ill and complained of much pain. After the second application by means of a small condenser electrode improvement began, the pain subsided, the patient slept well, and after fifteen sittings the visible growth had disappeared. The pathological report was a spindle-celled sarcoma.

Two cases of recurrent scirrhus of the breast also yielded to the treatment.

A fourth case was one of epithelioma of the cervix which had been given up as hopeless by two doctors. The cervix was completely involved, the patient weighed 6 st. 5 lb., and looked and felt very ill. The case being a desperate one, daily applications of from forty to sixty minutes were given by means of a condenser electrode passed up to the cervix. After about six weeks' treatment a very severe reaction set in accompanied by rigors. Three weeks later treatment was resumed with signs of improvement. The local condition did not alter much, but the pain and discharge decreased, sleep and appetite returned; the growth seems to be entirely arrested; present weight, 7 st. 10 lb.

Dr. Allan adds, "We must not hastily jump to conclusions about this new treatment, but we seem to be on the threshold of a very important therapeutical discovery which will bring relief and health to those suffering from a malignant disease which up till now has baffled the medical world."

Xanthoma.

(Syn.: *Xanthelasma, Vitiligoidea*)

Definition.—A fibro-fatty neoplasm forming yellow plates or nodules in the corium (Crocker). Two forms of the disease are recognised—Xanthoma planum and Xanthoma multiplex.

Xanthoma planum.—This is the more common form of this rare affection. It is characterised by the occurrence of small, flat pin-head and finger-nail size plaques, which vary in colour from a pale yellow to a much darker shade. They are circumscribed in character, are situated in the corium, and are very little if at all raised above the surface; the usual site is the eyelids, more especially near the inner canthus, from which they may spread to involve the surrounding skin. With a lens the patches may often be seen to consist of an aggregation of small yellow granules, which usually have a central pinkish puncture. There are little or no subjective symptoms.

Xanthoma multiplex (*Xanthoma tuberosum*) is a more rare and also a much more serious affection. The most characteristic sites are on the extremities, especially on the parts subjected to pressure. The nodules vary in size from a hemp seed to a pea, but by fusion they may form a swelling as large as an orange. Occasionally the mucous surfaces of the mouth, of the respiratory and gastro-intestinal tracts are involved, as also the surfaces of the peritoneum, endocardium, and larger arteries. The genital region, palate, œsophagus, spleen, trachea, and cornea have all been recognised as seats of the disease. Papular and tubercular lesions may coexist with the plain lesions above described, and scarcely differ from the latter save in a greater development. The lesions are whitish or yellowish papules, plaques, and tubercles, circumscribed in contour, covered with an unaltered epidermis, and determinable by palpation as having greater consistence than the flat macules. In rare cases the tubercles may coalesce to form sessile or pedunculated tumours, which are firmer as a rule than the smaller lesions (Hyde). In some cases the disease is accompanied by a general yellowish discoloration of the skin. Disfigurement is the chief symptom complained of. Occasionally pricking sensations are present. The *etiology* of the disease is quite unknown. The *pathology*, according to Chambard, is as follows:—There are two processes going on, an increase of connective tissue and a fatty degeneration or deposition, the results of a chronic inflammatory process, in the soft plaques the fatty change, and in the nodules the connective tissue growth predominates, being greatest in the larger and firmer ones.

The diagnosis is easy if regard is had to the peculiar yellowish or saffron-like hue of xanthoma. Multiple dermoid cysts may simulate.

Treatment.—Erasion and excision are the usual methods of treatment. Electrolysis is of great service in some cases; and various caustic applications have been recommended.

XANTHOMA DIABETICORUM.—This is an extremely rare affection. It is very fully described by Crocker, from whose description the following account is given. The eruption consists of dull red discrete or confluent papules quite firm to the touch, from a line to a quarter of an inch in diameter, well defined at the margin and roundish or obtusely conical. On the top of many of them, but not of all, is a yellowish or yellowish white head, which looks like a pustule, but is really solid, and some of the papules are dotted or streaked with red from dilated vessels; a red areola is sometimes seen. Itching, pricking, or tenderness is generally felt in the lesions. The most common situations are the buttocks, elbows, and knees, where they are generally confluent, and may form tumours though the papular origin is generally still discernible. They have also been seen on the trunk, on the extensor surfaces generally, on the mucous membrane of the mouth, on the face, scalp, and bend of the ankles. The eruption comes out rather suddenly at first upon the extensor aspect of the limbs, especially the forearms, and then more gradually in other parts; after remaining stationary for some time—months or even years—the papules begin to disappear, leaving no trace behind them, or while some disappear others come out; or again they may disappear entirely for a time and then break out once more.

Etiology.—Males are affected much more than females. The disease is one of adult life. Most cases are accompanied by true diabetes mellitus.

Pathology.—The diseased process is anatomically of the same nature as ordinary nodular xanthoma, but with more inflammatory phenomena and less connective tissue growth. With regard to its pathogeny, in diabetes as in jaundice, disorder of the liver exists, but the clinical facts show that derangement short of that necessary to produce either diabetes or jaundice may yet produce xanthoma.

Diagnosis.—Those who separate this form of xanthoma from all others base the difference between them upon the following points (Hyde):—

1. In xanthoma of glycosuria the sudden evolution and involution of the cutaneous lesions.

2. The firmness and solidity of the latter as distinguished from the softness of the ordinary forms.

3. The inflammatory character of the glycosuric as distinguished from the hypertrophic changes in the other variety.

On the other hand some authorities urge that the glycosuria is simply an initiatory cause, which explains the differing symptoms of xanthoma in the two classes of cases. Surveying the literature of xanthoma, they find patients without diabetic symptoms suffering from atrocious pruritus and most of the special features claimed as peculiar to diabetic xanthoma of glycosuria. The general conclusion arrived at is that it is difficult to determine what are the relations, if any, between these two forms of xanthoma.

The treatment of the disease, medicinal and dietetic, is mainly that of glycosuria.

Xeroderma pigmentosum.—A rare disease which commonly commences in the first or second year of life and progresses continuously. It commences with freckle-like pigmentations, surrounded in a year or two by telangiectases; this is followed by a gradual disappearance of the latter and the occurrence of cicatriform depressions; there is finally a diffuse atrophy of the skin. New pigment spots continue to form, so that a given case usually presents all types and grades of lesions. The general health seems to be unaffected. The *etiology* of the disease is quite unknown. The *pathology* probably begins as a proliferation of connective tissue in the papillary layer with involvement of the vascular endothelium, followed in some points by retraction and in others by both ectasis and new formation of vessels. Kaposi, who first named and described the disease, considers that the irregular accumulation of pigment is consecutive to the vascular changes. The diagnosis has to be made from scleroderma and lepra maculosa. The prognosis is guarded; there is a distinct tendency for the disease to assume a malignant (sarcomatous) form. Most cases succumb in from ten to twenty years. *Treatment* is purely palliative.

Xerosis.—Xerosis is a term applied to a condition of skin intermediate between ichthyosis simplex and keratosis pilaris. The skin is dry, harsh, and void of the natural moisture and lubrication. The skin surface is finely scaly, and in some instances the passage of the hand over the skin surface will cause separation of scales in a fine shower. In other cases the scales are more definitely adherent. The eruption is most frequently seen in the extremities, but all parts of the skin may be involved. The disease is met with in all grades, being sometimes only indicated by a very dry finely scaly condition of the skin of the face, and at the other extreme by a state of "goose skin" appearance, characteristic of mild cases of ichthyosis. The treatment and prognosis are similar to those of ichthyosis, to which article the reader is referred. One word, however, may be said *re* the etiology of this affection, supplementary to what has been written *re* the etiology of ichthyosis. The present writer believes that xerosis, ichthyosis, and allied disorders, are disorders largely due to some defect in metabolism of fats in the body. Further, that this defect is closely related to a defect in the bone marrow function. And, further, that both of these defects are in turn related to, and in great part dependent on, a chronic auto-intoxication from the alimentary tract, or one of the other free mucous surfaces of the body. This view may or may not be correct. In all cases, however, the practitioner is directed to a close investigation of the functions of the free mucous surfaces of the body, more especially the oro-, gastro-intestinal, and respiratory mucous membranes, with the view of correcting any defect that is there discernible on careful investigation.

Xerostomia. *See* Salivary Glands.

Yawning.—Yawning is a physiological expression of fatigue. It consists of the following phenomena:—

1. A deep inspiration, with elevations of the vomer and palate.
2. A forcible spasmodic depression of the lower jaw.
3. A flow of tears.
4. A clicking sound in both ears.
5. A tendency to stretch the limbs, especially the arms.
6. An expiration, often accompanied by a sound, the character of which has probably given the name to the act (Poore).

We know little or nothing of the cause of yawning. It is a passing phenomenon, which is removed by rest.

Yaws.

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Synonyms.—*Frambœsia, Pian* (West Indies); *Buba* (Brazil); *Coko* (Fiji); *Tonga* (New Caledonia); one of the varieties of *Paranghi* (Ceylon); *Bouton d'Amboine* (Moluccas); *Patek* (Sumatra); *Dubea, Ajortor,* or *Tongara* (Gold Coast); *Ogodo* (Sierra Leone); *Effier* (Benin); *Soombah, Gattoo, Framosi, Tetia, Momba* (various West African names); *Kwena* (Burmah); *Lupani* (Samoa); *Purru* (Malay Peninsula).

Definition.—A specific constitutional and communicable disease, occurring almost entirely in the tropics, and chiefly manifesting itself by an eruption of reddish tubercles on the skin.

History and Distribution.—Although the disease probably existed much earlier than 1648, the first definite account of it was then given by Pison (1). It is generally supposed that West Africa was the original home of yaws, and that by means of the slave trade it spread to the West Indies and South America, but this would not altogether explain its occurrence in Oceania. However this may be, its headquarters at the present day are unquestionably tropical Africa, and more particularly the West Coast, the West Indies, Samoa, Fiji, New Caledonia, and other Pacific islands. It is also common in Ceylon, Java, Sumatra, the Moluccas, and in Brazil, Guiana, and Venezuela. It occurs, too, in Assam and Borneo, and occasionally in Northern Africa and in India. By the adoption of careful measures of segregation it has been greatly lessened in some West Indian islands (Dominica) in which it was formerly frequent. In Barbados it has practically disappeared.

Clinical Features.—The incubation period lasts from two to ten weeks, and is usually unattended by symptoms. Although, in the inoculation experiments of Charlouis (2) in 1880, the average period was about fourteen days, and in those of Paulet (3) twelve to twenty, there is a general consensus of opinion that in naturally-acquired yaws it is longer.

The disease is frequently ushered in by a febrile attack lasting from a day to a week or more. This is occasionally severe and attended by marked pains, anorexia, anæmia, and so on; but, on the other hand, is sometimes so slight as to be unnoticed. Deep-seated rheumatic pains are, however, usually noted, and these, together with the fever, may recur throughout the illness, preceding the successive crops of yaws. Otherwise the general health is unaffected, unless from such complications as severe ulceration a cachexia is induced. Following these symptoms a papule occasionally appears at the site of inoculation, or if the latter be an already existing sore this becomes unhealthy, or a small ulcer forms. When the primary papule occurs it does not differ from the ordinary eruption, and is not comparable to the initial hard chancre of syphilis.

The eruption gradually develops, and may present itself in the form of squamæ, papules, or tubercles. Owing to its occurrence in crops all these varieties may be present together, but are really stages of the same eruption. During its development the glands, locally or generally, often become enlarged and tender. The first cutaneous symptom is a dryness and harshness of the skin, followed shortly by the development of irregularly-scattered desquamating patches, varying in shape.

This squamous stage (pian dartres, yaws cacca) varies in extent, and may be extremely slight, but occasionally involves the entire body. Sometimes it is persistent or appears at a late stage. On the dark skin of the negro well-marked patches are very prominent.

In these patches, after some days, minute papules appear and gradually push their way through the epidermis, which splits over them and curls away from their summit. Later, these (pian gratelle) become capped by a spot of a characteristic cheesy, yellowish discharge, and may then gradually disappear or enlarge into the typical granulomata. Like the squamous form, however, they sometimes persist as papules, and constitute a most obstinate and long-continued type of eruption.

The fully-developed tubercles vary in size from a split-pea to a golf ball, are rounded and hemispherical, or where very large or pressed upon, more flattened, and are covered by a cap of the same yellowish discharge. They may coalesce and form a large irregular patch, and are particularly apt to form clusters about the corners of the mouth and nostrils, where too, from the moisture, they become like condylomata, bare and sodden. During the development of the eruption itching is troublesome, and a peculiar musty smell often accompanies it. The crust, although firmly adherent, can be removed painlessly, and the surface underneath is insensitive, a somewhat important diagnostic point which is used as a rough test by West Indian negroes, who squeeze the juice of a lime over it. After removal the growth is seen to be grey or red in colour. Some oozing of blood may occur from it, and it at once begins by pouring out fresh cheesy secretion to form a new cap. The yaws vary greatly in number, size, and distribution; they may be localised or general, but are apt to involve the exposed parts, face and limbs rather than the trunk, and the scalp is usually unaffected.

They do not involve the mucous membranes except around the mouth, nose, and anus; and this, according to Nicholls (4), occurs in about 2·8 per cent. Near a nail they may cause a troublesome onychia. Several surrounding an area of healthy skin constitute "ringworm yaws." When, as not infrequently happens, one yaw grows much more rapidly and to a larger size than the others, it is often particularly persistent and obstinate, and constitutes the so-called mother-yaw or mama-pian. Situated on the sole of the foot (tubboes), from the pressure of the thickened skin the yaw is forced out in a coral-like formation, undermining the latter, and from tension and the irritation of walking this form is extremely painful. Finally, it undermines the epidermis with pus, ruptures it, and appears as a fungoid, often fœtid, tumour (crab-yaw).

Although ulceration is not a normal part of the history of a yaw, it occurs in a certain proportion, and may spread beyond them, producing extensive sores with resulting deformity from cicatrisation. It is due to the entry of pyogenic organisms, and probably varies with constitutional condition and care in treatment. Nicholls' estimate of 8 per cent seems somewhat low in the writer's experience in Africa.

This stage of eruption may last from weeks to years. Occasionally many recurrences may take place after apparent convalescence (memba yaws), and extend the duration to years. The tumours mature in about a fortnight, remain stationary perhaps for a time, then the crust shrinks, darkens, dries, and finally falls off, leaving a pigmented spot.

Any acute intercurrent disease may result in the disappearance of the eruption, although this is, as a rule, only temporary. It has been seen after remittent fever, dysentery, and so on. One attack usually confers protection, but true second attacks have been recorded.

Complications and Sequelæ.—In addition to the not infrequent ulceration attacking the growth itself, a form of serpiginous ulceration of the limbs has also been described. Powell (5) has recently reported swelling of the phalanges as occurring in a mother and child during the third year of illness. Both conditions are decidedly rare. In Fiji, where syphilis is unknown, lupoid ulceration of the soft palate or nose and gummatous nodes or thickenings have also been reported by Daniels (6), Corney (7), Finucane (8), and others; and very similar symptoms were recorded by Rat (8*a*) in the West Indies. This, however, is not the general experience, and there seem to be some differences between yaws in Fiji and that usually seen in Africa and elsewhere.

ETIOLOGY.—That yaws is communicable may be regarded as proved by numerous accidental inoculations, and by the experiments of Charlouis and Paulet, who successfully inoculated cases artificially. The teaching of experience would also seem to show that it can be propagated by contact, but that some solution of continuity of the skin is necessary. Thus, vaccine vesicles, ulcers, including those of syphilis and leprosy, the bites of leeches, ticks, mosquitoes, or other insects, scratches, or other wounds, may all act as portals to the virus of the disease. Overcrowding, filthy habits, and defective diet naturally predispose to and aggravate its attacks. Sex has no special influence, but the age of greatest liability is that from five to fifteen, although no age is exempt.

Its essentially tropical distribution and the far greater liability of negroes as compared to white men are also well-known facts. The comparative immunity of Europeans is doubtless largely due to the protective influence of clothing, their greater attention to hygiene and avoidance of yaws patients, and of overcrowding. Second attacks occur and have been produced by inoculation (Charlouis), but are not common, and natives in Fiji expose their children to infection with the idea that their health is subsequently improved. A very similar idea prevails in some native villages on the Niger. A form of yaws occurs in fowls, but animals are not subject to it as they are to verruga.

Infection appears to cling to huts, and after heavy rains outbreaks occasionally occur, due probably to the inhabitants being more confined to their huts on these occasions. The common house fly and the clothes and mats of infected persons are, with considerable reason, regarded as frequent vehicles of infection.

Relation to Syphilis.—By Hutchison (9) and others yaws is looked upon as possibly the parent form of syphilis, and as merely that disease modified by race, climate, and erratic modes of infection. By the majority of those, on the other hand, who have studied it in its own haunts, it is regarded as a distinct disease, and the writer's experience in Africa leads him to a similar opinion. Finucane's recent description, however, of Fijian yaws would seem to indicate a far closer resemblance to syphilis than is usual elsewhere, although Daniels considers the type in Fiji and in the West Indies to be identical.

The chief argument (and one apparently unanswerable) against the identity of syphilis and yaws is the occurrence of authentic cases of their co-existence. In some of these yaws patients contracted typical hard sores, and were cured by antisyphilitic treatment without any corresponding effect on the yaws.

The latter differs, too, from syphilis in its localised distribution, its longer incubation, its different mode of infection, and age of incidence.

It also occasionally occurs in outbreaks, and it resists antisyphilitic treatment. In addition, the primary lesion (if present) is not indurated; the effect on general health is usually slight, and febrile attacks may produce improvement; the type of eruption, unlike that in syphilis, is constant; the mucous surfaces, eye, and testicles are practically immune; and unless from entry of pyogenic organisms the lesions are not destructive.

Then the disease is auto-inoculable (Charlouis), no undoubted hereditary or congenital cases have been recorded, and mothers suffering from it have frequently been delivered of healthy children. In some Niger villages, where a large proportion of the children were affected by yaws, the writer failed to find evidence of congenital syphilis. Nor has he found the acquired disease in the tropics to differ in any degree from the ordinary type among Kroomen, in whom it is extremely common. Lastly, the morbid anatomy of yaws shows points of divergence from the syphilitic lesion. The granulation cells are not definitely grouped, and are unaffected by hyaline degeneration; there are no giant cells, the vessel walls are unthickened, and the epithelium is more markedly altered, while the stroma is less evident (M'Leod).

Histology.—With the exception of some proliferation of the fibrous structures (Nicholls), no marked change is found internally, unless from concomitant disease. In the skin the first change noted is slight dilatation of vessels in the papillary layer, but without alteration in their walls, together with some leucocytic extravasation. A few scattered infiltrations of granulation cells are seen near the vessels, and also slightly around the follicles and coil-glands, although these are themselves unchanged. These granulation cells are oval and polygonal, and have large eccentrically placed nuclei (plasma cells).

Simultaneously the inter-papillary epidermis grows down, and its cells become enlarged and œdematous. The superjacent stratum granulosum is involved, cornification is interfered with, the nuclei of the cells persist, and lamellæ tend to form in the stratum corneum. This vascular dilatation, epithelial proliferation, and œdema and imperfect cornification, produce the scaly lesions. Later the infiltration with granulation cells becomes more general and denser around the vessels, follicles, and glands. Here and there are large connective tissue cells, but no attempt at organisation. An attenuated fibrous stroma supports the cells. The inter-papillary processes of epidermis grow farther down, and the greatly lengthened papillæ approach the horny layer, while many leucocytes are seen between the prickle cells. Although cornification is imperfect it proceeds actively, and the horny layer becomes greatly thickened, but composed of still-nucleated cells, and separated into lamellæ divided by layers of leucocytic débris and fibrin. Pigmentation diminishes or disappears at the centre of the lesion, but returns after healing, chiefly in the lower epidermic layers. Most of the melanin granules are contained in the cells of the basal, and to some extent of the granular layer, but are occasionally inter-cellular, and when they surround a connective tissue simulate a branching pigment cell (M'Leod).

Bacteriology.—The numerous organisms present in the skin increases the difficulty of isolating the one responsible, and although several have been described, in no case yet has the evidence been completed by successful inoculation.

Pierez (10) found a micrococcus on the surface of the skin and in the horny layer. He also obtained it in the blood, and from the latter made cultivations. He found a similar organism in fowl yaws. Nicholls also invariably obtained in the growths a micrococcus from $\cdot 5\,\mu$ to $1\cdot 5\,\mu$ in diameter, which occurred either singly or in twos, threes, fours, short chains, or small colonies, and multiplied by transverse fission. It was never present in the blood, but in one case was seen in the fibrous structure of lungs, liver, kidneys, and spleen—a fact which might possibly explain the body pains. Pure cultures to the third generation showed a white, mucoid, oval, or rounded mass, not so well displayed in fluid media. Cultures were also obtained from the dust of yaws hospitals, but inoculations on animals were again negative. Powell also, after careful preparation of the skin, made successful cultivations of a staphylococcus in 24 cases, and in 2 he found a yeast, the presence of which might, he thought, explain the acid reaction of the discharge. Breda (11) described a bacillus (Frambœsia bacillus) as invariably present in the epidermis and corium, and Boyden and Hamilton (12) obtained cultures in the case of the former of a bacillus not unlike bacillus subtilis. In none of these cases, however, was the evidence completed by successful inoculations.

Diagnosis.—A solitary initial papule might, perhaps, be mistaken for oriental sore, but the progress of the case would soon decide the diagnosis, and syphilis is practically the only disease that can be confused. Geographical considerations and other differences distinguish verruga.

Prognosis.—Nicholls gives the mortality in the West Indies as 25·8 per 1000, chiefly from intercurrent disease. By cachexia or debility it may predispose to or increase the severity of subsequent disease, and the multiple skin lesions give opportunities for entrance of the germs of phagedæna, tetanus, and so on, but otherwise the general health is rarely much affected.

Prophylaxis.—The comparative immunity of Europeans and the effect of segregation indicate that the most efficient means of prevention consists in avoiding of overcrowding and dirty clothing, care about abrasions, and isolation of the sick. Thorough purification or destruction of infected huts and clothes, the local treatment of the tubercles, and their protection from insect carriers of infection, are similar useful measures. All precautions should be taken in vaccinating in yaws districts, more especially during outbreaks.

Treatment.—General: Anæmia and debility should be counteracted by plenty of nourishing, easily digested diet, and tonics. Chill should be avoided, as tending to repress eruption, and the patient's hut, therefore, should be warm and dry. Diaphoretics and aperients are useful in favouring the eruption, and sulphur and bitartrate of potash are frequently prescribed during the early stage, and are also sometimes useful later. When the eruption is out—mercury, iodides, and sarsaparilla are extensively given, but the former, from its tendency to produce anæmia, should be cautiously prescribed. Arsenic is particularly valuable in badly developed cases, and may be given as Donovan's solution. Powell, with the object of producing a curative febrile condition, has inoculated cases with Haffkine's comma bacillus, and suggests a similar trial with the erysipelas germ. It seems possible that thyroid extract would produce the effects of the febrile state without the obvious disadvantages of this treatment, and it has been tried in Trinidad with favourable results (De Verteuil). At a later stage various tonics, such as iron, quinine, and arsenic, are sometimes indicated.

Local: Various applications have been recommended. Carbolic, chromic, picric, and salicylic acids, nitrate of silver and sulphate of copper, and many forms of mercurial ointments, may be used. Ulcerating tubercles should be touched with carbolic, cleansed with lotion, and dressed with iodoform or other antiseptic. Crab yaws are best treated by prolonged soaking in hot lotion and removal of the skin covering them, and subsequent application of copper sulphate or calomel ointment. Cleanliness of the skin is most essential, and sea-bathing is strongly recommended.

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SYNONYMS.—Typhus icterodes (Cullen): *Fr.* La fièvre jaune; *It.* Febbre gialla; *Span.* Fiebre amarilla; *Ger.* Das Gelbfieber.

DEFINITION.—*Clinically*, yellow fever is characterised by a single paroxysm, lasting usually from three to five days, accompanied by frontal and supraorbital headache, injection of the conjunctivæ, flushing and puffiness of the face, severe pain in the loins and lower extremities, gastric distress, retching or vomiting, with a diminished secretion of urine. A fall in the temperature may now end in convalescence, or the remission be followed by yellowness of the skin, scanty albuminous urine, increased gastric irritability, hæmatemesis (black vomit), and other hæmorrhages. *Pathologically*, yellow fever gives rise to extensive fatty degeneration most marked in the liver and kidneys.

VIRUS OF YELLOW FEVER.—It is needless to mention the various organisms that have from time to time been announced as the cause of yellow fever. Their claims have been finally disposed of mainly through the laborious researches of Sternberg. The *Bacillus icteroides* discovered by Sanarelli in 1897 appeared to answer more or less fully the requirements which determine pathogenicity, and was accepted by some of the best authorities as the cause of the disease. The American Commission appointed to investigate the nature of yellow fever, consisting of Wasdin and Geddings, as the result of a long series of observations and experiments, reported in 1899, "that the micro-organism discovered by Guiseppe Sanarelli, and named by him *Bacillus icteroides*, is the cause of yellow fever." They base this conclusion on the following grounds: 1. They succeeded in isolating the bacillus from the blood in thirteen out of fourteen cases of undoubted yellow fever, and in 85·7 per cent of their necropsies. They thus assume that the organism is present in *all* cases of the disease. 2. They failed to find it in the blood of those suffering from, or in the bodies of those that had died of, other maladies. It is not therefore, they urge, a microbe of secondary infection. 3. They instituted numerous experiments on animals with the bacillus in pure culture, and found it to produce a fever running somewhat the same course, accompanied by many of the symptoms, and, in fatal cases, presenting lesions analogous to those of yellow fever.

A more critical examination of the facts has raised doubts as to the pathogenicity of this organism. It has not been proved that the bacillus is present in every case of yellow fever. Some competent observers have failed to detect it in a considerable proportion of cases. Sanarelli himself was able to isolate it in 58 per cent only of his necropsies. Nor has it been satisfactorily established that it is peculiar to yellow fever. Other organisms, again, are capable of producing symptoms and lesions somewhat similar to those caused by the *Bacillus icteroides*. Nothing is really known of the effects of living cultures on man. Those engaged in culture experiments on the bacilli of plague and cholera have accidentally contracted these diseases. Nothing of the kind has happened to those experimenting with this bacillus, even when it has been diffused through the air of the laboratory. The serum of animals rendered immune by injections of the *Bacillus icteroides* has not, so far as it has been tested, proved prophylactic or curative in yellow fever. Finally, the serum of yellow fever fails in many cases to agglutinate the *Bacillus icteroides*. It may thus be safely affirmed that its causal relation to yellow fever has not been established.

Nothing need here be said of the bacillus discovered by Durham and Myers in 1900, as no evidence of its pathogenicity has hitherto been adduced.

The Rôle of the Mosquito in the Transmission of Yellow Fever.—It will be convenient to notice here the evidence bearing on the communicability of yellow fever by infected mosquitoes and by the blood of those suffering from the disease. Finlay of Havana has maintained for nearly twenty years that yellow fever is propagated by the mosquito, and has based a system of prophylaxis on this hypothesis. Mosquitoes fed on a yellow fever patient are applied to a healthy subject, after an interval of two to five days, who by this means is believed to acquire a mild but protective form of the disease. Finlay's statements were never taken seriously by the profession. As to the main point—the communicability of the infection by the *Culex fasciatus* (Fabr.), or more correctly the *Stegomya fasciata*—

recent observations confirm his contention, although they go, at the same time, to show that the mosquito is incapable of communicating the infection or of conferring immunity so soon after contamination as his theory postulates. This point, like many others, requires more careful investigation.

The experiments of Reed, Carroll, Agramonte, and others render it practically certain that the infected mosquito is capable of communicating yellow fever. A special sanitary station was fitted up in an isolated, well-drained, and airy spot near to Quemados in Cuba, and every precaution was taken to prevent contamination from without. The results, briefly stated, were, that of ten non-immunes bitten by mosquitoes fed on the blood of yellow fever patients not less than twelve days previously, eight contracted the disease—the incubation period varying from forty-one hours to five days seventeen hours. Other experiments—of which, however, we have not the details—have since been conducted, and entirely confirm the earlier observations. In most instances the disease thus communicated has been of a mild type, but recently three fatal cases of experimental yellow fever have been reported, and it has been found necessary to impose restrictions on these experiments.

The fact that the experiments have been conducted in a yellow fever country detracts somewhat from their demonstrative value. But it is to be remarked that the subjects were placed in quarantine for a period of from nine to twenty-one days before being bitten, and it is specially significant that only those in the station bitten by infected mosquitoes took yellow fever, and that it appeared in them within the usual period of incubation. It would, nevertheless, be desirable that the experiments be repeated in a country free from yellow fever.

That the disease following the bite of the infected mosquitoes was true yellow fever hardly admits of a doubt. As these investigations have been conducted by competent and responsible men, and carried out with reasonable care, it may be accepted as proved that yellow fever is communicable by mosquitoes fed on yellow fever blood. Further, as the mosquito is incapable, according to these observations, of communicating the disease for ten or twelve days after feeding, the insect cannot act as a simple transporter and inoculator of the virus, but as a *host* of the parasite, which must be supposed to undergo either multiplication or development in the culex, in a manner analogous, perhaps, to that which takes place in the case of the parasite of malaria in the anopheles. Hitherto the parasite of yellow fever, whether bacterial or protozoal, has not been discovered either in the mosquito or in the blood of the patient, although the latter has been examined microscopically, times without number, by the most skilled observers furnished with the best appliances. The infective blood does not contain any microbe that can be grown on any ordinary medium.

Carter has shown that when a yellow fever patient is introduced into a place previously free from the disease, an interval of ten to twenty days usually elapses before the occurrence of secondary cases.[1] This fact finds an apparently satisfactory explanation in the circumstance, that about twelve days are necessary for the mosquito to become infectious. An infected house or ship on this hypothesis will mean one in which contaminated mosquitoes are present. We shall have occasion, however, to point out in the sequel that instances are on record in which the interval between the primary and secondary cases has been considerably less than twelve days. It may also be noted in passing, that Kermorgant, in his account of the epidemic at Senegal in 1900, expressly says: "Quand l'épidémie a commencé à Dakar, il n'y avait pas de moustiques." This, perhaps, should not be taken quite literally, for mosquitoes are never altogether absent from these regions.

Admitting, then, that the mosquito transmits yellow fever, many points will have to be worked out before we can hope for much light on the etiology and prophylaxis of the disease. Is the *Stegomya fasciata* the only mosquito capable of communicating yellow fever? Does the insect transmit the infection to its progeny? Can the mosquito become infected in any other way than by feeding on the blood of a yellow fever patient? Can man contract the disease in any other way than by the bite of an infected mosquito? How far does the transmission of the infection by the sole agency of the mosquito harmonise with and explain the limitation of yellow fever to particular zones, to seaport towns, its persistence in ships, and other well-ascertained facts in the epidemiology and etiology of the disease?

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[1] This is by no means a new observation. Griesenger, half a century ago observed: "On remarque encore que très souvent il y a un intervalle de huit jours à trois semaines entre un première cas qui se développe et l'invasion consécutive de la maladie chez un autre."

Other experiments made at the same station seem to prove that yellow fever is communicable by subcutaneous injections of the blood of the sick, taken from twelve hours to two days after the commencement of the fever. In six out of seven experiments of this kind the result was positive. The amounts injected varied from 2 c.c. to 0·5 c.c. The refractory patient was believed to be naturally immune. Another experiment is reported in which the injection of half a centimètre cube of blood from an experimental case gave rise to yellow fever. Until the converse experiment, however, is made, and mosquitoes fed on the blood of a patient suffering from the fever caused by these injections is proved capable of communicating yellow fever to healthy persons, some doubt must remain whether the fever so induced is caused by the parasite itself or by a toxin present in the blood. It is asserted that yellow fever has been communicated by blood passed through a Berkefeld filter. This requires confirmation. The specific virus is destroyed by subjecting the blood to a temperature of 55° C. The chief significance of these experiments lies in the promise they afford of putting us on the track of a parasite that has hitherto evaded detection. A careful and critical investigation of the facts bearing on the etiology of the disease is now more than ever necessary.

ETIOLOGY.—*Distinguishing Characters of Yellow Fever.*—Yellow fever is distinguished from other pestilences: (*a*) By its tendency to invade and cling to ships, and by the extent to which its spread is dependent on maritime commerce; (*b*) By its predilection for towns, especially those situated on the sea coast and on the borders of navigable rivers, and by the rarity with which it invades rural districts; (*c*) By the tenacity with which it clings to particular houses and localities; (*d*) By its epidemic range being confined to warm climates, and its prevalence in these restricted to the warm season; (*e*) By the extreme variations it exhibits in its spreading power, and in the mortality it causes in different localities and outbreaks; (*f*) By the marked influence of race, nationality, and acclimatisation on susceptibility to infection.

Endemic Centres.—Yellow fever is endemic in the West Indies, whence come the first quite reliable accounts of the disease, reaching no farther back than the year 1647. A second centre is found on the West Coast of Africa, its limits here including Sierra Leone, the Gambia, and Senegal. The first historical outbreak on the West Coast occurred in 1759. Rio de Janeiro and the neighbouring coasts of Brazil form a third centre, where the disease has only become acclimatised since 1849.

In none of these centres, however, has the disease been continually present from the time when its presence was first noted. It has been absent, at least in a recognisable form, for years from every island in the West Indies, and from every locality on the West Coast of Africa and Brazil. Havana, until recently a hotbed of yellow fever, is believed to have been free from it from 1655 to 1761, a period of more than a hundred years, during which the town was reputed for its salubrity. The history of yellow fever points to it being carried by shipping from place to place within a certain zone, and from one zone to another, and persisting for a longer or shorter time in a given place according as conditions are more or less favourable, and then disappearing, until it is again introduced from without. It is thus endemic in zones rather than in places, and is probably maintained by the native infant population who have it in a mild form.

Epidemic Extensions.—Yellow fever was scarcely absent from one or other of the coast or river towns of the Southern States of the Union up to the last quarter of the nineteenth century. New Orleans, Charleston, and Mobile, from their proximity to the West Indies and their frequent intercourse with infected localities, suffered most. Baltimore, Philadelphia, and New York, on the middle Atlantic coast, were also frequently visited by the disease. Yellow fever appeared so far north as Quebec in 1805 and Halifax (Nova Scotia) in 1862. From the West Indies it has from time to time invaded Central America, Venezuela, Guiana, and Bermudas. With the exception of Peru, where the disease has shown a tendency to become acclimatised, the Pacific Coast of America has suffered little.

In Europe, Spain and Portugal have been the chief scenes of its ravages. The close commercial and political relations subsisting between these countries and the West Indies and Brazil, as well as their semi-tropical climate, account for the frequency and severity of the outbreaks of yellow fever from which they have suffered. Indeed, some of the epidemies in Spain have been incomparably more fatal than any recorded in the countries where yellow fever is endemic, falling as they have done on a susceptible population. The disease has always declared itself in one or other of the seaports—Cadiz, Malaga, Barcelona, Gibraltar, or Lisbon, and has generally been confined to these. In 1800-1804, and again in 1819-21, yellow fever penetrated for a considerable distance inland, and maintained itself for some time in a quasi-endemic manner. Leghorn experienced a fatal outbreak in 1804. It has frequently been introduced into the harbours of France and England, but has rarely spread on shore, and never to any extent. Yellow fever was brought into Swansea from Cuba in 1864, and caused sixteen deaths on shore. The East Coast of Africa, the northern parts of Europe, the whole continent of Asia, Australia, and Polynesia have hitherto remained exempt. Its latitudinal limits have been Monte Video in 34° 54′ S., and Swansea, 51° 37′ N.

Epidemic Characters.—Yellow fever never appears in a seaport outside its endemic limits excepting after the arrival of a vessel from an infected port. An epidemy begins by one or two cases, which generally declare themselves near the shore—in the custom-house, or in the quarters frequented by sailors or those employed in discharging vessels. After an interval, not uniform, and often not very accurately recorded, but which may be stated as from ten to thirty days, secondary cases appear in the house or vicinity of the primary case, or among those who have visited the infected house. As new foci are established the circle of infection widens, and the disease first assumes epidemic proportions after the lapse of six weeks to two months. It is important to bear in mind that as the disease extends the interval between primary and secondary cases appearing in houses situated in districts and suburbs previously exempt often does not exceed a few days. A patient, for example, residing in a hitherto healthy suburb contracts the disease. Other cases immediately follow in the same house. The patient is removed to another house for treatment, and the inmates of his new quarters are in turn seized with fever in three or four days after his arrival. Several instances of this kind will be found in the report of the Lisbon epidemy of 1857 (see also *Bérenger-Féraud,* pp. 546 and 598). Instances such as these, and they are somewhat numerous, should not be ignored merely because they do not seem to harmonise with any of the current theories of infection.

In most instances yellow fever is restricted to particular localities, especially the insanitary quarters of the town, where the streets and lanes are narrow, overcrowded, badly ventilated, and imperfectly exposed to the sun's rays. The progress, extent, and duration of an epidemy are largely dependent on season, temperature, local conditions, and the susceptibility of the population. When the whole community is susceptible, and climatic and other conditions are favourable to its spread, it may invade a whole city, as happened to Barcelona in 1821, where 70,000 attacks and 20,000 deaths took place in a population of about 80,000.

The first cases are, as a rule, most fatal. At St. Louis in 1900 the case-mortality at the beginning was 72·2 per cent. When the outbreak was at its height it fell to 49·2, and in the period of decline to 40 per cent. It occasionally happens, however, that the disease is mild at the commencement, and increases in virulence as the epidemy declines. In most outbreaks abortive cases occur, marked by gastric troubles, headache, loin pains, and slight icterus. It has been observed that these mild attacks do not always confer an immunity. It has often been asserted that dogs, birds, and other animals suffer from symptoms analogous to those of yellow fever, when that disease is epidemic. This requires confirmation.

Yellow Fever as a Ship Disease.—Special interest attaches to ship outbreaks, both from the part which maritime commerce plays in the diffusion of yellow fever, as well as from the fact that the manner in which it is propagated often admits of being more closely followed on board ship than on land.

1. Ships are particularly liable to become infected. This is partly explained by the susceptibility of those on board, and partly by the habits of sailors, which lead them to frequent the most insanitary localities on shore. Still, we should hardly have expected that a disease propagated by mosquitoes should have shown that special predilection for shipping. Old wooden vessels often fall into an extremely insanitary condition, especially those engaged in the sugar, coal, and timber trades, and these are just the vessels most liable to become infected. Sailing vessels are often detained in the tropics by calms and contrary winds for weeks after leaving a yellow fever port, and this, no doubt, favours the outbreak of the disease. 2. Ship outbreaks often prove extremely fatal, especially in the case of crowded ships of war, where isolation and disinfection cannot effectively be carried out. Not to mention exceptional instances, it has been no uncommon experience of ships of war in comparatively recent times to lose during a short voyage one-half or one-third of their men by yellow fever. The *Eden* in 1829 lost 110 out of 160; the *Bann* in 1823 had 99 attacks and 33 deaths among 107 whites, while none of the 27 negroes on board suffered. The *African* in 1881 lost 18 out of 28, and *La Fortuna* in 1856 had 118 seizures and 56 deaths out of an effective of 212 men. In some few instances where the crew has numbered from 5 to 10 all on board have perished. 3. The virus of yellow fever often clings to a vessel with extreme tenacity. The *Eclair* ship of war was infected in July 1845, and notwithstanding efforts at disinfection she carried the disease with her to England in September, and communicated it to the pilot and several others who had to board her. She lost during the voyage about 60 out of 140 men. After wintering and undergoing repairs and cleaning in England, yellow fever once more broke out on board in the following year when the vessel entered the tropics. Still more remarkable is the case of the United States cruiser *Plymouth*, in which yellow fever reappeared after she had been disarmed, discharged, exposed during the winter to a mean temperature of 28° F., scraped, twice fumigated with sulphurous acid, and washed with chloride of lime. On dismantling the vessel a second time, flies were found between the boardings which had survived the cold and fumigations to which the vessel had been exposed. But it is somewhat difficult to believe that mosquitoes, so sensitive to cold, and whose term of life does not appear to exceed seventy-five days, could have survived the cold for so long a period. 4. A vessel on which the disease has once appeared often proves highly infectious as soon as the holds are opened, and although fresh cases may have ceased to occur among the passengers for a considerable time. The history of the *Anne-Marie* is of peculiar interest in its bearings on many questions connected with the etiology of yellow fever, as the facts were investigated with a thoroughness and recorded with a precision that give them the value of a scientific experiment. The following account is condensed from the original report:—

The *Anne-Marie*, an old wooden vessel, laden with sugar, left Havana on the 13th of June with a crew of sixteen, and arrived at St. Nazaire (France) on the 25th of July 1861, having had nine cases and two deaths from yellow fever during the voyage. The first case appeared on the eighteenth and the last on the twenty-ninth day after leaving Havana, where yellow fever then prevailed. As no fresh case had occurred for thirteen days the vessel was admitted to pratique, the crew discharged, and seventeen labourers belonging to the port engaged to unload her. None of the crew of the infected vessel took ill after landing, and there is no very clear evidence of their having communicated the disease on shore. The work of unloading began on the 27th July, and was finished on the 3rd of August. All the labourers engaged in this work were infected, and nine died; the first case occurring on the sixth, and the last on the twelfth day after the work of discharging began. Four of the sick labourers returned to their homes in the country, six to ten kilometres distant from St. Nazaire. They were attended by a local practitioner, Dr. Chaillon, who had never been near the infected vessel. He continued to visit them for eight days. Two days after his last visit (that is, ten days after his first contact with the patients) he was seized with yellow fever and died. A stonecutter working on the quay about 600 feet to the leeward of the vessel, but who had neither visited the ship nor had any intercourse with those on board, was attacked on the 4th of August and died. The *Chastang*, a tug vessel with five hands, lying close to the leeward of the *Anne-Marie*, was infected, the first case appearing on the 1st of August. All five were attacked in succession and all died. Four other vessels to the leeward, two of which were not in direct contact with the *Anne-Marie*, also furnished fatal cases. Vessels to the windward, although equally close to the focus of infection, escaped. A shoemaker, who is said to have shared his bed with one of the labourers, was attacked and died; and two women who, it was believed, had been in the company of the sailors, and had obtained some articles of dress from the vessel, were likewise seized with yellow fever, but the precise mode in which they were infected was not satisfactorily ascertained. There were, in all, 44 cases and 26 deaths.

The cessation of the disease on board during the latter part of the voyage while the vessel, as was afterwards proved, was so severely infected, is no less remarkable because it is what is observed in the majority of these instances. The fact that the second officer who had escaped during the voyage fell a victim while superintending the discharge of the cargo proves that the arrest of the disease on board was not the result of all the susceptible having been attacked. The two incidents, however, of greatest etiological significance in this history is the infection of the stonecutter and that of Dr Chaillon. The case of the stonecutter proves conclusively that the virus or its bearer is transportable for a distance of at least 600 feet by the wind, and it is certainly as conceivable that a mosquito from the vessel communicated the disease in this case as that an infective dose of a bacillary virus should have been diffused through the atmosphere for such a distance. Dr Chaillon must have contracted the infection in one of three ways: (*a*) By the agency of a mosquito contaminated on the spot by one of the patients, but for this the time was insufficient if reliance can be placed on recent observations; (*b*) By an infected insect or a virus transported from the vessel in the clothing or effects of the sick, and thus the case would be one of transmission by clothing. (*c*) Directly from one of the patients whom he was attending. This last mode is that which naturally suggested itself to those who made the inquiry, and they looked upon it as all the more probable from the circumstance that the doctor was short sighted, and had to come into very close proximity to the patient he was examining. He was also very assiduous in his attendance on the sick, and personally and perseveringly applied frictions to one of his patients. There is no great difficulty in admitting the possibility of an infected mosquito, fragile as it is, being carried from the ship in the clothing of a patient; but this would be, after all, of the nature of an accident, and it would be somewhat surprising if this mode of transport should have happened at the same time in the case of the shoemaker and the two women, all of whom contracted the disease without having had any direct communication with the infected ship.

Topographical and Altitudinal Relations.—Yellow fever, as we have seen, is distinctively a disease of river and sea-ports—a peculiarity, as Hirsch observes, "without analogy in the history of other infective diseases." Instances of yellow fever breaking out in inland towns have become more numerous since railways have rendered communication with infected ports more rapid. These inland outbreaks have never, however, exhibited great spreading power, nor has the disease become endemic in localities remote from the sea. It has never become diffused in rural districts, which are those most liable to malaria. Although generally restricted to localities near the sea level, yellow fever has occasionally broken out at higher elevations—Madrid (2000 feet), Cordova in Mexico and São Paulo in Brazil (2500 feet), and at Newcastle in Jamaica (4000 feet), above the sea level.

The physical and geological characters of the soil have no influence on the prevalence of yellow fever. Unlike malaria it has no preference for marshy localities. When the French army was encamped near the marsh of Téjeria (four leagues from Vera Cruz, where the disease was decimating the troops) the soldiers suffered terribly from malaria, but were almost exempt from yellow fever. It has often been observed to prevail with special severity where extensive excavations have been in progress.

Meteorological Relations.—In the regions where yellow fever is endemic its wide diffusion is commonly limited to the warm season. In higher latitudes, epidemics uniformly begin in summer or autumn, decline as the temperature falls, and are, in most instances, extinguished when the thermometer reaches freezing-point. The disease, however, will maintain itself for a time at a much lower temperature than that necessary to set it agoing. The influence of rainfall and humidity is less evident, but it is to be remarked that in all its endemic centres yellow fever attains its maximum in the rainy season.

Conditions affecting Susceptibility; Race.—Apart from acclimatisation the negro race exhibits a marked resistance to the infection. The Soudanese troops, 400 in number, forming part of the French expedition to Mexico, and stationed in towns where yellow fever was working havoc among the French and Mexicans, remained completely exempt. This resistance to the infection could not be ascribed to an immunity acquired by their having already had the disease, as these negroes came from a region where yellow fever is unknown. In some epidemics the negro population, acclimatised for generations to the conditions met with in the States, has paid a considerable tribute to the malady, but, as a rule, when the negro does take the disease it is in a comparatively mild form. In the Decatur outbreak of 1878, for example, the case-mortality of the whites was 44, that of the coloured population 13 per cent. Natives of the north of Europe are more susceptible to yellow fever and suffer from a more severe type of the disease than those from the south. Blair found the case-mortality of the Italians and French to be 17·1, that of the Scandinavians and Russians 27 per cent.

Acclimatisation.—Natives of, and those who have been long resident in, yellow fever countries are seldom attacked when the disease is epidemic. That the immunity of the native is in part at least the result of his having already passed through the disease is shown by the fact that when yellow fever was introduced for the first time into Rio the natives suffered as much as strangers. We can give no explanation of the remarkable difference in susceptibility between the natives of the north and south of Europe. One well-developed attack usually confers an immunity for life.

Age; Sex; Profession.—Yellow fever is most fatal to adults. In infants and young children the disease is often so mild that it is with difficulty to be distinguished from other febrile diseases common to that age. Yellow fever, for some reason, is nearly twice as fatal to males as females. Physicians and nurses in yellow fever hospitals have often enjoyed a remarkable exemption when the disease has been epidemic in a town, and this has been urged as a proof that yellow fever is not infective. There are numerous instances, however, in which those in attendance on the sick have suffered out of all proportion to the community generally. Thus, among the French soldiers at Vera Cruz in 1862, of 46 attendants detailed for the service of the yellow fever wards, 43 (93 per cent) were attacked and 18 died, while the rest of the troops stationed in the same town had rather less than 20 per cent of attacks. So perilous, indeed, did this service prove that the authorities had to employ Soudanese negroes to nurse the sick. These, as we have seen, exhibited an inexplicable refractoriness to the virus. Medical men, if unacclimatised, often pay a heavy tribute to the infection. Thus, in Senegal in 1830, eight out of twelve; and in 1878, twenty-two out of twenty-seven medical officers perished. Those who visit the sick in their homes are more frequently seized than those who are on hospital duty. It is difficult to understand why in one epidemy all the attendants should escape, and in another almost all should be attacked, except on the assumption that some intermediary, not always present, is necessary for the transmission of the infection.

Labourers engaged in discharging infected vessels, Custom-house officers having to deal with baggage from infected ports, washerwomen employed in washing infected linen, and bakers, are especially liable to be attacked.

Predisposing Causes.—Every kind of excess has been alleged to predispose to the disease, but it is impossible to determine what influence, if any, is to be ascribed to these causes. On one point there is practical unanimity—that the risk of contracting yellow fever is much greater by night than by day.

Sources of the Virus.—There can be no reasonable doubt that the virus, whatsoever it may be, multiplies in the body of the patient, and that the patient himself is the primary source of infection. The doctrine of Hirsch, Scheube, and others, that it is not the yellow fever patient, but the yellow fever *place* that infects is wrong, in so far as it ignores the fact that the place is directly or indirectly contaminated by the patient.

Modes of Transport and Transmission.—We have already seen the important part played by shipping in the diffusion of yellow fever. The instance of the *Anne-Marie*, and we might have adduced many others, is conclusive that the germ of the disease or its bearer is transportable for short distances by the wind. It is equally well established that the virus is transported from place to place by persons actually sick, or in the incubatory stage of the disease. It is probably spread largely by those suffering from mild or abortive forms not recognised, which may explain a considerable number of what have been looked upon as spontaneous outbreaks. How long the patient remains infective is unknown. The important question remains, whether the virus can be transported in contaminated clothing. Too much value is not to be attached to the negative experiments recently made in Cuba. They certainly do not justify the inference of the Commission "that the disinfection of clothing, bedding, or merchandise supposed to be contaminated is unnecessary." If any amount of negative evidence could prove the non-communicability of the infection by contaminated clothing, the immunity of those employed in handling and washing the linen in the Lazaretto of Philadelphia for a long series of years, that of those similarly employed at Bermuda in 1843, and in the colonial hospital at Demerara in 1841-45, would suffice. But it is impossible to ignore well-authenticated instances which seem to admit of no other explanation than that the virus of yellow fever is, in certain circumstances, transmissible by clothing and other effects. The Lisbon outbreak of 1857 began in the custom-house. It was custom-house officers, soldiers, and guards, whose duty it was to inspect and unpack the baggage coming from Brazil, or to be present in the low, unventilated rooms where this baggage was stored, it was these who were first attacked, it was by these exclusively that the infection was first spread, and it was these who suffered most. Eight out of nine custom-house officers so engaged died of this disease, and scarcely less was the mortality of those on guard at this store. The baggage store was clearly the primary focus of the infection, and it was equally evident that this focus was not established by the presence in it of a person sick of yellow fever. In what way did it become infected if not from contaminated baggage? How are we to explain the Madrid outbreak of 1878 if yellow fever cannot be transmitted by fomites? A body of troops returning from Cuba to Spain remained in perfect health during the voyage. On arriving at Madrid their baggage, which had not been opened from the time they left Cuba, was unpacked. A small outbreak of yellow fever followed, limited to the inhabitants of the district where the returned soldiers were quartered, they themselves, being acclimatised, escaped. It was observed here, as at Gibraltar in 1829, and at Ascension in 1838, that the washerwomen who were employed to wash the soldiers' effects were amongst the first to be seized. To mention one other instance scarcely less free from ambiguity: a medical officer, M. Massola, who had been on duty at the yellow fever hospital and post-mortem rooms at Gorée in 1878, was ordered to proceed to Bakel, a post on the Upper Senegal, 470 miles from Gorée. He left on the 15th, and reached his destination on the 29th of July, and was assisted by a soldier attached to his service, belonging to the post, in unpacking his luggage, which contained the non-disinfected clothing he had been using in the hospital. On the 16th of August this soldier was seized with yellow fever, and in succession seven out of the eight Europeans at that remote post were attacked and died of the disease. Strain (*Journal of Tropical Med.*, April 1899) relates several instances of yellow fever at São Paulo in the interior of Brazil, following the unpacking of boxes and cases from the infected port of Santos. If infected mosquitoes can be stowed away for months in the hold of a ship, it may be contended that there is no improbability in the supposition that they may be conveyed in luggage, but this must be impossible for long distances, if it be the case, as Reed asserts, that the mosquito deprived of water dies within a few days. Some doubts must be entertained of the accounts of the germs lurking in clothing, bedding, sails, and other articles for periods of two or three years, or even longer; but whatever explanation may ultimately prove correct, the transmissibility of the infection of yellow fever by fomites appears to be conclusively established.

Clinical History.—The attack is occasionally preceded, for a few hours or even days, by headache, giddiness, lassitude, loss of appetite, and gastric discomfort, but the cases in which premonitory symptoms are observed are comparatively few. The invasion, which often occurs at night, is announced by a chill or rigor, violent in proportion to the impending attack, although it is well to bear in mind that in malignant cases the chill is more frequently absent. The temperature, which has already begun to rise before the chill, reaches from 102° to 104° F. within the first twenty-four hours. The pulse at this stage is fast, strong, and full, but even as early as the second day it begins to diminish in frequency and force, although the temperature persists or continues to rise. This want of correspondence between the pulse and temperature is of considerable diagnostic value. The face is red or livid and swollen. The eyes brilliant and injected. Photophobia, pain in the eyeballs, distressing frontal or orbital headache, intense lumbar pains radiating towards the pelvis, and articular and muscular pains in the lower extremities, are the symptoms most complained of by the patient at this stage. From the onset there is a feeling of weight and pain in the epigastrium, with anorexia, nausea, a varying degree of thirst; and, after a time, in all but the mildest cases, retching or vomiting. Vomiting usually makes its appearance on the second day, first of the contents of the stomach, then of a clear or bile-tinged acid fluid mixed with mucosities. The tongue is moist, contracted, coated with a white fur, and red at the tip and edges. The gums are often swollen and bleed readily. The urine is generally reduced in quantity, is high coloured, often turbid, acid in reaction, and from an early stage contains traces of albumin. The bowels are constipated.

This state of things lasts for two, three, or four days, according to the gravity of the case. The fever, which is of the sub-continued type, now begins to fall. The pulse tends to regain its normal characters, and the conjunctivæ often, at this stage, begin to assume a yellow tinge. A more or less marked amelioration takes place, which may end in recovery or be followed by grave symptoms.

When recovery is about to ensue the nausea and vomiting abate, the appetite returns, the temperature falls, the urine becomes more abundant, and the albumin disappears.

But the lull, instead of heralding recovery, may be but the prelude to the evolution of a new train of phenomena characteristic of the malady and of grave significance. This issue is to be feared if the gastric distress persists during the lull. There may now be a secondary rise of one or two degrees, or the temperature may persist about the point reached after the remission, or in the worst cases a rapid fall below the normal takes place with symptoms of collapse. It is during this second stage that jaundice, hæmorrhages, and algidity develop. The pulse sometimes becomes abnormally slow, occasionally sinks to forty a minute, less frequently it is weak and accelerated. The conjunctivæ, skin of face, neck, and upper part of chest assume a tint varying from a straw colour, easily overlooked, to a deep saffron or even bronze hue. In a considerable number of even severe cases distinct jaundice only makes its appearance after death. Gastric irritability, which had temporarily subsided, recurs. The vomited matters begin to show dark grains or flakes—the precursors of the black vomit. Quantities of a fluid resembling coffee-grounds are now ejected. This black vomit, so characteristic of yellow fever, is only one sign of a hæmorrhagic state which frequently manifests itself in epistaxis, oozing from the lips, gums, tongue, ears, or eyes, by hæmorrhages from the bowels, bladder, and uterus, and by ecchymosis into the skin. In malignant cases slight pressure will cause blood to ooze from the tongue as from a sponge. During this stage the urine is scanty, always highly albuminous, and may or may not give the reactions of bile. Sometimes it is suppressed. The excretion of urea is notably decreased, and its accumulation in the blood gives rise to the symptoms of uræmia. The bowels are relaxed, the motions black and tarry or dark and watery.

Recovery not infrequently takes place after all of these symptoms in a minor degree have developed. An increase in the urinary secretion and a diminution in the albumin are the most hopeful signs. This is generally followed by an abatement of the vomiting. When the disease has reached this stage, if the patient escapes with his life, convalescence is protracted.

Death usually occurs from a combination of causes—enfeebled circulation and impeded respiration, with exhaustion from fever, vomiting, and hæmorrhages, and the depression of the nervous system resulting from the presence of urea and other toxic substances in the blood. A fatal termination takes place, as a rule, from the fourth to the eighth day. Relapses are most frequent after abortive cases.

In most outbreaks a considerable proportion of the cases terminate favourably in the first stage. The symptoms, in fact, may be so mild that the true character of the disease is overlooked. At the other extreme are cases of great severity running a rapid course. In these, as we have already said, rigors are generally absent. There is extreme prostration from the very commencement, with coldness of the extremities, vertigo, dilated pupils, profuse multiple hæmorrhages, stupor, delirium, coma, or convulsions, death taking place within thirty-six or forty-eight hours. Each epidemy has its own character. In the Lisbon outbreak of 1857 algidity was the distinguishing symptom. The external temperature fell below the normal; the pulse was small, feeble, and sometimes fast, the features shrunken and livid, the skin generally cyanosed and covered with purpuric spots, the extremities deeply livid and cold, with oozing of blood from nose and gums, black vomit, and almost total suppression of urine. In some epidemies, again, vomiting, purging, cold sweats, and prostration have replaced the ordinary symptoms of the first stage.

Complications.—The more common complications are parotitis of one or both sides, boils, carbuncles, abscesses (if large a good sign), and erythema of the scrotum. In Senegal two cases of gangrene of the extremity of the penis were observed.

The following charts (pages 549 and 550) represent the more common types of temperature curves—the last three fatal.

Morbid Anatomy.—Rigor mortis appears early, and is extremely marked and persistent. The skin and tissues are almost invariably jaundiced, and hypostatic suffusions particularly pronounced and diffused. The axillary, femoral, or mesenteric glands are often enlarged (Durham).

The membranes and substance of the brain and spinal cord are often highly congested. The lungs and bronchial tubes are more or less congested, but present no characteristic lesions. The pericardium is occasionally ecchymosed, and may contain a moderate quantity of yellow serous or sanguineous effusion. The heart may be either normal in appearance or pale and flabby. Small ecchymotic points are often found in the substance of the organ. The muscular fibres may be normal, or present distinct evidence of fatty degeneration.

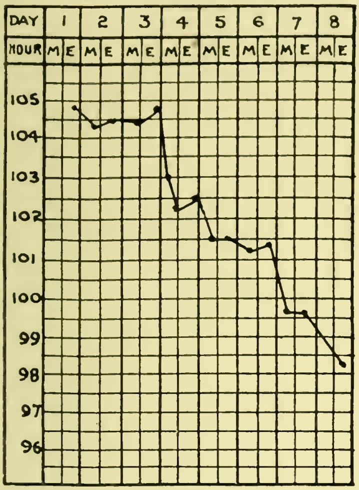

Chart 1.

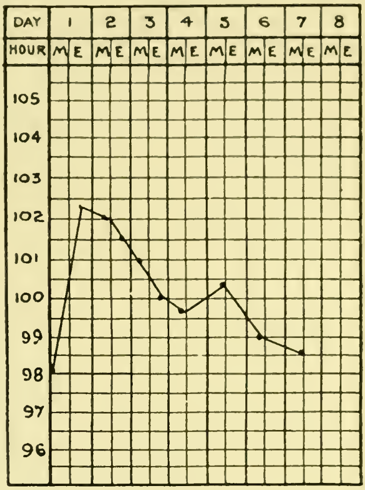

Chart 2.

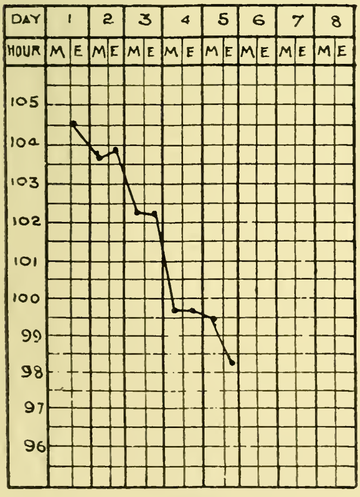

Chart 3.

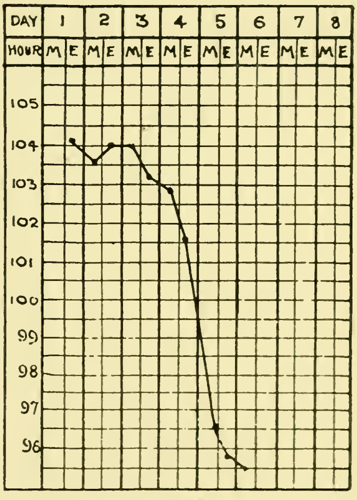

Chart 4.

The liver is normal in size, and varies in colour from a buff to deep lemon colour. The specific gravity of the hepatic tissue is reduced in proportion as the yellowness is more developed. The hepatic cells are in a state of fatty degeneration, with partial or complete necrosis of the cell. The fatty changes are more marked in some portions of the liver than in others.

The spleen is normal in size, colour, and consistence, unless the patient has suffered from malaria.

The stomach often contains more or less of a fluid similar to black vomit, and presents patches of congestion, hæmorrhagic suffusions, and catarrhal thickening of the mucosa. The small intestine frequently contains a fluid similar to that found in the stomach. The mucous membrane is arborescent in patches. The large intestine is normal.

The kidneys are frequently congested and swollen when death has taken place very early, otherwise they are normal in size and colour. They are always the seat of diffuse parenchymatous nephritis. The epithelium of the convoluted tubules are specially involved and undergo fatty degeneration, necrosis, and desquamation.

Diagnosis.—Attention to the state of the spleen, and a careful examination of the blood and urine, taken along with the circumstances of place and the history of the case, will suffice to distinguish yellow fever from the bilious hæmorrhagic form of malaria and from hæmoglobinuric fever, the only diseases with which it is likely to be confounded.

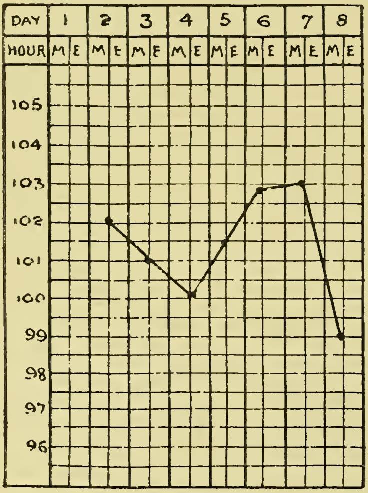

Chart 5.

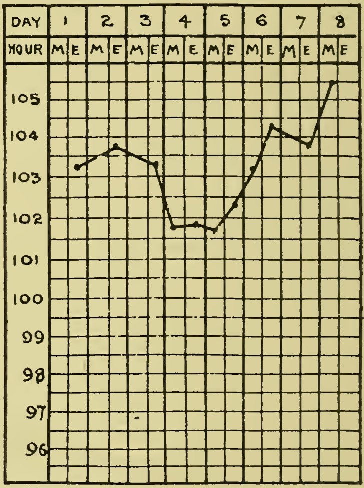

Chart 6.

Mortality and Prognosis.—The proportion of a susceptible population attacked varies greatly in different epidemies. The civil population of Gibraltar in 1804 numbered 14,000. Of these only 25 escaped, 12 of whom had already suffered from the disease. More commonly the diffusion of the infection is limited to the poorest and filthiest parts of a town. The case-mortality exhibits extraordinary extremes, varying from ½ per cent in New Orleans in 1897 to 87 per cent in the same city in 1853.

The prognosis must thus have regard, in the first place, to the type of the prevailing epidemy. The age and nationality of the patient has also to be taken into consideration. A severe, long-continued chill, a high temperature, extreme irritability of the stomach, and, above all, scanty and albuminous urine, indicate a severe attack. A fall of the temperature below normal with signs of collapse, generalised hæmorrhages, suppression of urine in the second stage, are separately of the gravest import, and combined prognosticate a fatal issue.

Prophylaxis.—The stamping out of the disease in its endemic foci is obviously an object of primary importance which has never been seriously taken in hand. For the accomplishment of this object the extermination of mosquitoes should be attempted by all the methods adopted in the case of malaria. The low-lying districts of sea-ports within the yellow fever zone should be drained, surface pools and other collections of water dried, waterbutts and cisterns covered, and every breeding-place of the *culicidæ* abolished. Scarcely less important is the widening and opening up of narrow streets and lanes to sun and air, and the prevention of overcrowding. As there is reason to believe that native children maintain the infection, their febrile complaints should be attended to, and the contamination of mosquitoes prevented by surrounding their beds with mosquito netting. Were these measures vigorously carried out there is good reason to hope that this scourge might be greatly mitigated.

To prevent the infection of ships in ports where the disease is present, they should be moored at some distance from the shore or an infected vessel. As mosquitoes are conveyed from shore in lighters this mode of infection should be guarded against. It has been suggested to fumigate them with sulphur before they are brought alongside the ship. Unacclimatised sailors should be prevented from landing, especially by night.

When the disease makes its appearance on board a vessel while in harbour the sick should be removed to hospital, the crew and passengers transferred to a quarantine station or camp, the cargo disembarked, and the vessel disinfected by sulphurous acid or formaldehyde, clothing and bedding by steam, and the furniture and decks by solution of corrosive sublimate.

When yellow fever declares itself at sea the sick are to be isolated, and the infected quarters evacuated and disinfected. When possible, a course should be steered for colder latitudes. For preventing the introduction of the disease into healthy towns reliance is to be placed on the inspection of vessels from infected ports, the isolation of the sick, and the supervision of the healthy. Disinfection is as necessary in the case of vessels having had the disease on board during the voyage as in the case of those on which there are sick persons on arrival. Detention, however long, is no safeguard.

The principal means of combating the disease when it appears on shore are prompt isolation of sick and contacts, and thorough disinfection of the houses and belongings of the sick. When these means fail the evacuation of the infected district has been carried out with the best results. When yellow fever breaks out in barracks the men should be camped out, all contaminated baggage, bedding, and clothing being left behind for disinfection, and the camp changed if fresh cases should occur. Susceptible persons should remove from an infected locality.

Treatment.—It is of primary importance to remove the patient, when possible, from the focus of infection to a healthy locality. A marked amelioration of the symptoms is often found to follow the removal of a patient to an airy room in a healthy part of the town.

In the milder cases the treatment should be mainly hygienic. Constipation is to be obviated by purgatives, the action of the kidneys promoted by alkaline drinks, and the temperature moderated by tepid spongings. Constipation is generally present, and in the more severe cases, at least, it is well to administer at once 5 to 10 grains of calomel, followed next day by sulphate of sodium. The calomel may sometimes be advantageously repeated, as, apart from its purgative and bactericidal properties, it has often a marked effect in diminishing gastric irritability. Castor oil is a favourite purgative with some, but its nauseous taste not infrequently brings on troublesome or even dangerous vomiting. Experience sanctions the use of a warm mustard foot-bath at the beginning of the illness. The feet and legs are placed in water as warm as can be borne, to which mustard has been liberally added, and the patient is enveloped in a blanket

This promotes perspiration, and relieves, temporarily, the headache and pains, and, if the perspiration be free, the fever is lessened.

When the temperature is high one or two doses of antipyrine, given at the early stage when the pulse is strong, is occasionally of service. In all but the mildest cases resort should be had to bichloride of mercury, in combination with bicarbonate of soda, as suggested by Sternberg. His formula is: bichloride of mercury, $\frac{1}{3}$ of a grain; bicarbonate of soda, 150 grains; water, 1 quart. Three table-spoonfuls are to be taken every hour ice-cold. This remedy has been found to allay gastric irritability and increase the urinary secretion. Under this treatment 374 cases treated by different physicians in the United States, Cuba, and Brazil, the mortality was 7·3 per cent. These results justify its use in all serious forms of the disease.

While this treatment is being employed two symptomatic indications must be steadily carried out, viz. to favour the elimination of toxins by the kidney and to moderate the fever. The issue of a case, so far as it is determined by treatment, will depend upon our success in meeting these indications.

The patient should be encouraged to drink freely of some mildly alkaline water. To those who can afford and procure it, from two to four litres of Vichy water should be administered daily. Aerated water, with the addition of 60 grains of bicarbonate of soda per litre, will answer if Vichy water cannot be had. The water should be given in small doses, say half an ounce to an ounce every quarter of an hour, either at the ordinary temperature of the room or ice-cold, as may be best supported by the patient. Should the water be rejected cold diluent enemata may be administered. The amount injected at a time should not exceed what can be retained and absorbed, and the injections should be repeated every two or three hours. As soon as the patient's stomach can bear it the alkaline drinks are to be resumed. The object is to promote the action of the kidneys and prevent the accumulations of toxins in the system. In severe cases, where the stomach cannot tolerate liquids, the subcutaneous injection of 200 to 300 c.c. of a sterilised solution of common salt ($2\frac{1}{2}$ drs. in 40 oz. water) may be of service.

When the temperature is under 102° F. the whole body—the back as well as the front of the trunk—and the limbs should be successively washed every two or three hours with a large towel wrung out of water at a temperature 80° to 85° F., a little higher or lower according to the sensations of the patient. When the temperature reaches 103°, and the skin is dry, ice should be added to the water to bring it to 60° or 70° F., and the washings repeated every hour. The higher the temperature the more ice is to be added to the water. That part of the body only which is being washed should be exposed. It should then be thoroughly dried and covered, and another part treated in the same way. When the skin is perspiring cold sponging should be avoided, and, indeed, in this case is not needed. When there is much heat and congestion of the head an ice-bag should be applied. These cold washings of the skin are agreeable to the patient, they moderate the temperature, increase the urine, and allay gastric irritability. When the temperature exceeds 104° F., and the measures recommended fail to control it, resort is to be had to the cold bath. The patient is placed in a bath at 85° or 90° F., which is to be reduced to 80° or 70° F., or lower, so as to reduce the temperature of the body by two degrees at least. Fifteen minutes will usually be sufficient to effect this, and the ordinary precautions to prevent collapse taken. In adynamic cases the warm bath or hot packs should be used. In cases marked by collapse, the application of heat and frictions to the extremities and subcutaneous injections of ether are called for. If the heart's action is feeble and irregular, digitalis in small doses along with stimulants should be tried.

Vomiting is one of the most distressing symptoms of the disease. The treatment already recommended, if systematically carried out, will do much to control it. Sinapisms over the epigastrium, a few drops of chloroform given at frequent intervals, drop doses of creasote, an ice-bag over the pit of the stomach, are the remedies most commonly employed. They are all occasionally useful, more frequently they all fail.

In hæmorrhagic cases little good can be expected from medicines. It was thought that the perchloride of iron in full doses was of some service in the Lisbon epidemy. Some recommend ergot hypodermically in these cases, but it is seldom of any service. It was in this form that King and Laird found advantage from the use of oil of turpentine in doses of 20 minims, in camphorated water, three times a day, a little spirits of nitrous ether being added if strangury occurred.

Diet.—During the first two or three days no food whatever, liquid or solid, should be given. When the fever has subsided and gastric irritability has disappeared, milk in small quantities, alone or mixed with lime water, should be given cautiously. As convalescence progresses chicken broth, or beef tea, and light farinaceous foods should be allowed. For some weeks after recovery the strictest regulation of the diet and habits of life should be insisted on to obviate the risk of relapse.

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Zinc Poisoning. *See* TOXICOLOGY.

APPENDIX

Plague.

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1. DEFINITION.—Plague is an acute infectious disease, caused by a specific bacillus and characterised by inflammation of the lymphatic glands, sometimes by pneumonia or septicæmia.

2. SYNONYMS.—Pestis, Pestilentia, Pestis bubonica, Clades inguinaria glandularia, Oriental Plague, Indian Plague, Pali Plague, Black Death, Die Pest, Beulen Pest, Peste, Pestilenza, Tschuma, Mahamari, and a great many other names, some of which signify "epidemic disease with great mortality," "the rat disease," etc., etc.

3. HISTORY AND GEOGRAPHICAL DISTRIBUTION.—The history of the distribution of plague epidemics divides itself into two portions: epidemics before and after 1894 A.D., in which year, in the outbreaks in Southern China, the present widely diffused series of plague epidemics commenced.

Regarding the early portion of plague history, little need be stated. In the writings of Rufus of Ephesus, reference is made to an epidemic of a disease in Egypt, Libya, and Syria, characterised by fever and buboes, about the beginning of the second century B.C. About the beginning of the Christian era another plague epidemic was noted in Libya by two Alexandrian physicians. We find no other certain reference to plague until the occurrence of the great *Justinian Plague* in the sixth century A.D., which ravaged the whole Roman Empire "to the ends of the habitable world." This lasted fifty or sixty years, and wrought most frightful havoc wherever it appeared. From the second half of the sixth till the fourteenth century many severe epidemics of plague harassed Europe. The *Black Death* of the fourteenth century is the next epidemic of plague of which we have much information. It is said to have started in Eastern Asia, and to have spread to Asia Minor, Northern Africa, and Europe, reaching the Crimea in 1346; by 1349 and 1350 it had overrun the whole continent of Europe. Hecker estimates the loss of life in this pandemic at 25 millions, about a quarter of the then population of Europe. Plague, with which is probably included several other epidemic diseases, continued to be prevalent in Europe throughout the fifteenth, sixteenth, seventeenth (in which occurred the *Great Plague of London*), and eighteenth centuries, sometimes affecting small areas, at other times in the form of a pandemic.

Towards the latter part of the seventeenth century plague appeared to be gradually retreating from Europe, and from the middle of the eighteenth century only the south-eastern parts of the continent were permanent seats of the disease. In the nineteenth century plague was epidemic in this portion of the continent from time to time till 1841, when, with the exception of an outbreak in 1879 in Astrakhan on the borders of Asia, plague disappeared from Europe till the localised epidemics which have occurred during the last few years.

Several *endemic centres of plague* have been recognised throughout the world, most of them for a long period, the chief of them being as follows:—

(1) The district of *Assyr*, in Arabia, on the eastern shore of the Red Sea.

(2) Portions of *Persia and Mesopotamia*.

(3) Southern China, especially the province of *Yun-nan* on the Thibet frontier.

(4) The districts of *Kumaon and Garhwal*, Upper India, on the southern slopes of the Himalayas.

(5) The district of *Kisiba* (German East Africa), and an adjoining locality situated in the south of the province of Uganda, to the west of Lake Victoria Nyanza.

(6) The *Transbaikal Province*, Eastern Siberia, and Mongolia.

(7) More recently Dr. Thiroux has added the *Island of Réunion*, where he alleges that plague, locally known as *Lymphangite infectieuse*, has existed in a mild form for many years.

The present history of plague distribution starts from the year 1894, when the disease assumed a new phase. Previous to this, plague had for a long period been confined to the nomadic tribes in Northern Persia and Central Asia, the Arabs in Assyr, and the Bedouins in Mesopotamia. The fresh characteristic which plague then assumed was to attack large and populous cities in Southern China and India, such as Canton, Hong Kong (1894), and Bombay (1896). Travelling down to Canton from Yunnan, near Thibet, the disease spread to Hong Kong and thence to Bombay. From Hong Kong and Canton many parts of China have become infected, and from Bombay plague has spread over a considerable portion of the Indian peninsula; in 1902 the epidemic wave extended over districts in India never before infected during the present pandemic, and as many as 80,000 cases and 61,000 deaths from plague have been reported from the Punjaub in a single month (March). Since 1897 Japan, The Philippines, Honolulu, Madagascar, British East Africa, Aden, Mauritius, Australia, South America, and South Africa have suffered, and nearer home Oporto, Alexandria, Port Said, as well as other towns, have become infected. Cases are continually being reported from the Levantine cities, and these, together with the repeated cases of the disease occurring on board ships arriving in European ports, make plague a very distinct danger to this country. Localised outbreaks, fortunately on a very small scale, have already occurred in Glasgow and Liverpool, but were soon suppressed by the authorities. The geographical distribution of plague at the present time, together with a history of recent epidemics, is considered at length in a special plague volume just issued by the Medical Officer to the English Local Government Board.

4. Modes of Entry and Means of Spread

A. Modes of Entry.—Plague may enter the body in three ways, by—(1) Inoculation; (2) Inhalation; (3) Ingestion.

(1) *Inoculation.*—The commonest mode of entry of the plague bacillus into the body is by the skin. This probably does not take place through unbroken skin, but through abrasions of various sorts, such as wounds, scratches, etc., and the bites or stings of insects. It is not necessary to suppose that the insect itself introduces the infection, but it is probable that this may enter through the bite, either by being already on the skin, when the insect bites, or by subsequent contamination of the wound. The irritation of the bite may sometimes produce scratching, which may be done with an infected finger, and in this way inoculation may occur. The rings worn on the toes in India and elsewhere, which are often associated with the presence of sores on the toes, may create a channel of entry for plague infection. In connection with this fact, however, it must be noted that it is the inguinal and femoral glands of those, such as Europeans, who usually go about booted which are chiefly affected.

The Indian Plague Commission, in investigating this point, found that there was a relation between the area of skin surface draining into a particular set of glands and the frequency with which those glands were affected. They found that while the areas of skin surfaces which drain respectively into the neck, axilla, and groin stand to one another approximately as 1:1·8:5, the hospital statistics at their disposal showed that the relation between the numbers of primary buboes in the cervical, axillary, and inguinal regions was 1:1·3:5·8. The explanation therefore of the more frequent occurrence of buboes in the groin seems to be that a much larger skin surface drains into these glands, and therefore the greater the skin surface, the greater the chance of infection of a region. As instances of infection by inoculation may be cited those cases infected at post-mortems by cutting the fingers, or through abrasions already present. In such cases a bubo subsequently develops corresponding to the site of inoculation. The frequency of buboes in the neck in children may be ascribed to their habit of putting things into the mouth, the channel of entry being cracked lips, or other wounds in that neighbourhood; or perhaps infection reaches the neck through the tonsil. There is a case recorded of a pneumonic patient spitting on to the conjunctiva of a nurse, who developed a cervical plague bubo. The site of inoculation is sometimes found as a small slightly inflamed papule or pustule, and the plague bacillus may in some cases be recovered from the point of entry. The glands corresponding to this pustule are those affected, and sometimes inflamed lymphatics may lead from the pustule to the bubo. As a rule one is unable to discover definitely the point of inoculation.

(2) *Inhalation.*—This is probably the mode of entry of infection in pneumonic and sometimes septicæmic plague. It is well recognised that exposure to an ill-ventilated atmosphere, charged with plague bacilli floating in the dust of such a room, is a common source of infection. This latter condition appears to have been the mode of infection at the "Wakes" held in the early Glasgow cases in 1900, where, among those who attended, several contracted the disease. In India this mode of infection is probably common in the ill-ventilated houses, which are dark, dirty, and densely crowded, and where the atmosphere is breathed over and over again, becoming laden with plague bacilli, and highly infectious to those inhaling it. In well-ventilated houses and hospitals, the atmosphere may be disregarded as a carrier of plague infection. This loss of infectivity of plague in the presence of efficient ventilation resembles closely what is observed in typhus fever. Kitasato claims to have demonstrated the presence of the *bacillus pestis* in dust from the walls of a room occupied by a plague patient. Experimentally, plague can be produced in rats by placing a small quantity of a plague culture on their nasal mucous membranes.

(3) *Ingestion.*—Beyond infection through the tonsil, which may occur in cervical cases, there is no evidence of the ingestion of food causing plague infection. Infected food might conceivably infect wounds on the hands or lips. Childe has stated, as a result of his Indian experiences:—"With regard to infection by food, no evidence was found post-mortem that the bacillus had entered through the stomach or intestine." The intestinal type of plague might be cited as a proof of food infection, but it is doubtful whether this type occurs apart from one of the other well-marked forms of plague. Rosenau states that the *bacillus pestis* can live a long time in milk, cheese, and butter, but it usually dies out quickly on the surface of fruits and prepared foods.

In animal experiments it sometimes happens that a healthy rat consumes the body of one of its own species which has succumbed to plague, without itself developing the disease. On the other hand, several observers note that in like circumstances such animals have contracted the disease in a virulent form.

B. MEANS OF SPREAD.—(1) *Plague in the Lower Animals and Infection to Man. Mammalia—Primates.*—The brown monkey (*Macacus radiatus*), the grey monkey (*Semnopithecus entellus*), and the bonnet monkey (*Macacus sinicus*) are all very susceptible to plague, and instances are reported from India in which monkeys have acquired the disease in nature. They can therefore aid in spreading the disease, though their influence is probably small.

Rodentia.—The grey rat (*Mus decumanus*), the black rat (*Mus ratus*), and the white rat are all naturally susceptible to plague, which may occur epidemically among them. The influence of these animals in diffusing plague will be considered presently. Mice, the pig rat or bandicoot (*Nesokia bandicota*), the grey striped squirrels of India, and possibly porcupines can naturally acquire the disease. Ferrets, used to exterminate rats, frequently contract the disease in plague-infected localities (*e.g.* South Africa).

Outbreaks have been recorded among small rodents of the nature of marmots, locally known as tarbagan (*Arctomys bobac*) in the Transbaikal Province of Eastern Siberia. This disease appears to be transmitted from the marmot to man, and upon the infection of one member of a household several cases in the family frequently occur. There is no doubt that this disease is true plague. It breaks out periodically in the marmots about the autumn, just before the hibernating season, the symptoms observed being, unsteadiness in gait, langour, and glandular swellings; the disease is very fatal (Clemow, *Journal of Trop. Med.*, Feb. 1900).

Marsupials.—Wallabies are reported to have become infected in Australia during 1902.

Carnivora.—Cats may acquire the disease, instances being reported from Australia, Mauritius, South Africa, and lately in British East Africa. Suspicious sickness and deaths among these animals have been reported on ships which have had human plague cases on board, sometimes before the manifestation of the disease in man.

Invertebrata.—Bugs, fleas, and flies have been supposed to act as carriers of plague infection, a subject which is dealt with later.

The Connection between Plague in Rat and Man.—The principal ways in which plague is believed to be spread are by contact directly with persons suffering from the disease or with material infected by such persons or plague-stricken rats.

Those epidemics of which we have fullest particulars naturally divide themselves into two classes, those in which rats have appeared to be the important carriers of infection, and those in which plague-infected rats have been absent or an unimportant factor.

Upon this classification we may draw up the following table, a few outbreaks of both types being selected from the many plague epidemics which have occurred of late years:—

Outbreaks in which Plague Rats have been important factors in spreading Plague.	Outbreaks in which Plague Rats have been unimportant factors.
Sydney, 1900.	Oporto, 1899-1900.
Cape Town Port Elizabeth Mossel Bay 1901-2.	Glasgow, 1900. Liverpool, 1901.
Report of Indian Plague Commission. Chak Kalal, Punjaub. Mahlgahla, Punjaub. Kurachi, 2nd epidemic. Poona, later epidemics. Belgaum, 2nd epidemic.	Certain villages in Punjaub. Kurachi, 1st epidemic. Poona, 1st epidemic. Belgaum, 1st epidemic.
Alexandria Port Said 1900.	

The Plague Commission summarised their views on the connection between plague in rat and man:

"It has been clearly established that when the infection of plague has been imported into a town or village, rats have, in many cases, contracted the infection before any indigenous case occurred among men. Again, it has been clearly established that, where rats have become infected, they have been instrumental in spreading plague in evacuated villages, and in carrying the infection outward from evacuated quarters. Hardly less clear is it that rats have been frequently at work in disseminating the infection of plague in inhabited towns and villages, and that in some cases they have been responsible for the occurrence of an explosive outbreak of plague among men. It is, however, important to note that the outbreak of plague among rats has not in all cases been followed by the occurrence of plague among men, and that explosive outbreaks have sometimes been due to causes other than the spread of infection by rats."

The following conclusions are therefore arrived at regarding the relative importance of rats and men as agents in disseminating plague in an infected place:

(*a*) "In some places where severe epidemics have occurred among men, rats have not been infected at all, and in many places where there have been plague epidemics among men, the disease has not appeared among rats in epidemic form.

(*b*) "Occasionally where there has been considerable mortality among rats, there has been an absence of plague among men.

(*c*) "Even when there has been the largest amount of plague among rats, the risk of persons who came in contact with these infected rats appears not to have approached that undergone by persons inhabiting houses[1] in which there have been plague patients, or persons coming into contact with pneumonic plague. There are, however, cases, such for instance as the cases of Mahlgahla and Chak Kalal (already referred to), where a very considerable number of plague cases in a village has been directly attributable to the dissemination of infection consequent on an epidemic of plague among rats.

(*d*) "Since the number of plague bacilli escaping from the infected human organism must be presumed to be greater than the number which escape from a plague-infected rat, *à priori* it would seem clear that a single infected man must constitute a greater danger than a single infected rat; but, on the other hand, seeing that the excreta of rats may be deposited anywhere throughout a house, and that the number of rats which are affected may many times exceed the number of men who are affected, a severe epidemic among rats must, we think, tend considerably to the spread of infection.

(*e*) "The chief importance of rats in the epidemiology of plague seems to us to arise in connection with the first outbreak of the disease in an affected place, for we have seen that in many instances rats become infected before men, and they scatter plague broadcast over an uninfected place.

(*f*) "When plague is once established in a place, we have no doubt that human agency is a more important factor in spreading the disease than the agency of rats." This last conclusion, however, cannot be applied to plague in South Africa, where infection from rat to man appeared to be the common mode of infection.

As to the manner in which the plague rat communicates infection to man, nothing very definite can be stated.

In the minority of cases direct contact with a recently dead rat can be ascertained. Usually only the presence of the plague rat under the floors and ceilings of the house, or among bales and boxes in the house or store can be proved. In rat-infested places their fæces are found all over the building, proving their wide distribution throughout the house, and we know that the bacillus pestis occurs in the urine, fæces, pus from buboes, and bronchial secretion of plague rats. Hence the infection of dust, food, clothing, and anything else in the house is extremely probable; in this way infection may reach man.

The rat flea theory of infection advanced by Simond is an attractive one, but sufficient proof of its truth has not been demonstrated. He holds that fleas from the infected rat become parasitic on man and inoculate him with the disease. In support of this he points out the phlyctenules, which are sometimes found on the same part of the body as the bubo, and which might be produced by a flea bite. This theory received some support in Sydney, and experiments made there to some extent confirmed Simond's views. Simond's experiments have, however, been adversely criticised by several writers.

Nuttall (*Journal of Trop. Med.*, March 1902), says: "The evidence in favour of the flea-hypothesis is worthless and cannot withstand scientific criticism." He found negative results in a series of experiments, but thought that flies (*Musca domestica*) might be a source of danger in disseminating plague.

Galli-Valerio found that the two varieties of fleas most commonly infesting rats and mice, the *Typhlopsylla musculi* and *Pulex fasciatus*, would not bite him, and readily left him unless confined on his body. The *Pulex erinacei*, which is also found on rats, bit man, but not readily. The common flea of dogs and cats, and sometimes found on rats, the *Pulex serraticeps*, readily bit man. All these fleas can be readily distinguished from the *Pulex irritans* which infests man. Galli-Valerio, therefore, came to the conclusion that *Pulex serraticeps* and *Pulex erinacei* might sometimes convey plague from rat to man, and that *Typhlopsylla musculi* could convey plague from rat to rat. The rat fleas which attack man are, however, either rare on the rat or do not readily bite man (*Journal of Trop. Med.*, 1st Feb. 1902, and *Centralb. f. Bakt.*, Band xxvii. and xxviii., 1900.)

I have myself rarely entered a plague-infected house in Cape Town or Port Elizabeth without experiencing several flea-bites which, however, proved non-infective, and this experience was shared by the numerous disinfecting gangs employed in such houses under my direction. Cases of plague among the disinfecting staff are uncommon, considering their frequent opportunities of becoming infected, but this may be due to their having been, in most cases, inoculated with Haffkine's prophylactic.

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[1] It is possible that in many of these houses plague rats were present about the house, under floors, ceilings, etc., or in outhouses.—*J.S.L.*

To summarise this subject, it seems probable, though the question cannot be considered to be settled, that while fleas may in some cases inoculate the disease or furnish in their bite an aperture through which plague infection may be introduced, the common method in which the rat infects man is by contact of abraded skin surfaces of man with material infected by plague rats.

(2) *Plague Infection from Person to Person.*—It is a recognised fact that plague in a well-ventilated hospital is only infectious to a slight degree.

The only cases which appear to be at all infectious in hospitals are the pneumonic and septicæmic cases. A well-known example of this was seen in the Vienna group of cases in 1898, in which a nurse and a medical attendant both contracted plague pneumonia while in attendance upon a case of this type of the disease. It is to be noted that plague pneumonia tends to reproduce itself, as is well seen in the *Backergunge* outbreak quoted by the Indian Plague Commission, where twenty cases of this type, extending through six generations of infection, occurred.

Bubonic cases are not as a rule very infectious, the bacillus being for the most part localised in the affected glands and their immediate surroundings, and only entering the blood stream towards the approach of death, *i.e.* when septicæmia has set in. Such cases might then become infectious by the agency of fleas (if such a mode of spread be accepted), and in addition, such cases are infectious through the lungs, fæces, urine, and hæmorrhages which may occur. As regards the infectivity of the urine, in Sydney, out of experiments in twenty-nine cases, ten showed plague-like bacilli in the urine, but these could not be isolated, and inoculation of animals furnished negative results. Further, plague bacilli failed to grow in human urine, whether sterilised by heat or by passing through a Pasteur-Chamberlain filter, and whether left acid or neutralised. On two occasions, however, growths on agar were obtained from the urine of guinea-pigs which had died of the disease. The bacilli of plague have been stated to have been recovered from the fæces, but most observers state that they have failed to do so. It is possible that the numerous difficulties attending the separation of the organism may account for their failure. It is necessary, therefore, to consider both the urine and fæces to be infectious, especially in septicæmic plague and possibly in other types, though the presence of the bacillus in these excretions has not been satisfactorily determined. The plague bacillus may also gain exit from the body when the bubo is opened, though here again many observers have failed to recover the bacillus from the pus of a discharging bubo. It has been done, however, and for an unknown length of time the discharging bubo remains a source of infection. In cases with parotid and submaxillary buboes, the *bacillus pestis* has been found in the saliva. In some plague epidemics pulmonary complications of varying degrees of severity occurred in a large number of cases as in the early part of the 1899 Bombay epidemic. Here, even where the lung changes were slight, plague bacilli were found in the sputum.

This part of the subject may be summarised as follows: Bubonic cases are at first little infectious, but upon the development of lung symptoms, septicæmia, or the opening of the bubo, become more infectious; primary plague pneumonia and septicæmia are infectious from the beginning, though this infection does not as a rule operate in well-ventilated houses or plague hospitals, in spite of the lack of personal disinfection and precautions on the part of the attendants on the sick. Plague in insanitary, plague-rat infected, or badly-ventilated houses becomes a very infectious disease.

(3) *Infected Clothes.*—Clothes can retain their infective property for a long period. Many cases are on record where evacuation of a village or houses has not at once checked the occurrence of plague cases among the inhabitants until their clothing has been removed and disinfected. Another fact bearing on this point is the heavy incidence of plague among the washerman class who have suffered severely in India. A case of this

nature occurred in Glasgow, where the wife of a man employed in collecting infected clothes contracted the disease, the husband, who had received a prophylactic dose of Yersin's serum, escaping infection. There are cases of discharged *employés* from plague hospitals infecting their families at home, probably due to the conveyance of infected clothing which had been hidden to escape steam disinfection.

Bacteriological examination has usually proved negative in the cases of clothes and merchandise, unless grossly contaminated. Infected clothing has played an important part in some cases in infecting sailors, who, upon arrival in port, have opened their boxes, or taken from the bottom of their boxes clothing obtained in a plague-infected port. Such cases occurred in London Docks in 1896, in men who had shipped from Bombay and who had arrived in London in a healthy condition. In some outbreaks, dealers in second-hand clothing, or persons engaged in rag-picking, have been the first attacked. Rosenau states that the bacillus pestis can live on clothes for months, when dry in albuminous media at a temperature under 20° C.

(4) *Infected Soil.*—The Indian Plague Commission note that the plague bacillus has not been recovered from the soil by any trustworthy observer in India. There are many difficulties in the way of such a research, and it is possible that these may yet be overcome. It is probable that the plague bacillus is frequently present on the surface of mud and cow-dung floors, from gross contamination by sputum, excreta, etc., and thus may infect the barefooted inhabitants of the house. As to a saprophytic existence of the bacillus in the soil we know little or nothing, though it has been observed that abundant growths occur in tubes containing plague cultures buried in the soil, possibly from the ample supply of CO_2, which appears to aid the growth of the organism.

(5) *Alleged Infection of Grain.*—When grain is artificially infected with plague, the bacillus soon dies out, and observers have failed to recover the organism after four to six days. In decomposing grain it dies out sooner, the acid produced being fatal to the life of the bacillus. From these experiments it would seem that grain, even if at first directly infected, would soon lose its powers of infection. From the actually infected grain must be distinguished cargoes or accumulations of grain infested by plague rats. In this case the epidemic may be carried on among rats, and on arrival at a port these rodents may infect the docks from communication between the ship and dock rats. The danger, therefore, in grain stores and grain ships does not appear to lie so much in the grain as in the rats with which they are associated. In other words, grain is no more dangerous as a source of infection than any other cargo or store likely to attract rats, and the danger lies in the rats and not in the cargo.

(6) *Water.*—The plague bacillus, according to most observers, readily dies out in water, though Rosenau states that the bacillus can live a long time in this medium. There are no grounds for supposing that plague has ever been a water-borne disease.

(7) *Plague-infected Houses.*—The common occurrence of plague-infected rats in these houses has already been referred to. Regarding the infectivity of the house in which plague has occurred, the Indian Plague Commission observe: "The universal experience of plague in India proves that houses, into which the infection of plague has been imported, whether by man or rats, are infective; this infectivity being so marked that many of the officers who have had most experience of the disease have come to the conclusion that the principal source of the infection is . . . to be found in the houses into which the infection of plague has been introduced."

The *bacillus pestis* has not been recovered from the mud or cow-dung floors in India, but this may be explained by the difficulties of the investigation, and not to the absence of the bacillus. Reference has already been made to the infectivity of ill-ventilated dwellings. In reference to infected premises, Chalmers has stated: "Except for the accidents of exposure to gross and probably prolonged contagion, it is necessary to live the life of the inhabitant in order to incur his perils. And peril exists wherever the surroundings are of a character so grossly insanitary as will afford the bacillus a suitable soil for saprophytic growth."

The influence of insanitary surroundings is also important in this connection, but is referred to in the succeeding section.

(8) *Insanitary Conditions.*—These must be considered as being intimately connected with plague infection for several reasons. In the first place, those living under such conditions have a weakened resistance towards infectious disease in general, and under certain conditions may become directly infected by living in an infected atmosphere vitiated by uncleanliness, insufficiency of ventilation, and overcrowding. This view has been held by Sir T. R. Fraser, the President of the Indian Plague Commission, who regards overcrowding as chiefly operating in adding to the air pollution, and that people living under such influences become predisposed to attack. He holds that the virulence of the plague organism becomes exalted by increase in moisture and CO_2 in the atmosphere, and elevation in temperature, diminution of oxygen, and deficiency of light. The majority of the Plague Commission were unable to accept the view that insanitation had any special influence on plague infection. In the second place, insanitary conditions are almost always associated with the prevalence of rats, and in a rat-borne epidemic these are the places which are naturally the first to become plague infected.

It is necessary, therefore, to regard insanitation always as a predisposing factor, and sometimes as directly connected with the spread of plague infection.

(9) *The Influence of Season and Temperature.*—Season appears to have some influence on the epidemicity of plague, but an epidemic of this disease may occur under any climatic condition. The first Bombay epidemic (1896) attained its maximum at the coolest period of the year, in December; the second reached its highest point as the weather was getting warmer, in February; in the third epidemic it was deferred till the month of March. It is noteworthy that the height of the epidemic has been reached in Bombay city in the month of March in the years 1898, 1899, 1900, and 1901. In all the Bombay city epidemics, the maximum has been reached in the early months of the year, the disease dying down in the hot weather, in May to July. Outbreaks in Calcutta and Kurachi occurred during the hottest season of the year, in Poona during the monsoon, and in the Southern Mahratta country at the close of the monsoon, while winter was coming on. The Cape Town epidemic of 1901 occurred towards the latter part of the hotter weather and during part of the cold weather when it subsided. A study of the scattered endemic centres of plague shows that the disease can remain endemic in the cold winters of Siberia as well as in the tropical heat of Central Africa.

C. The Spread of Plague from Place to Place

(*a*) By Land; (*b*) By Sea.

(*a*) *By Land.*—Plague may be conveyed to an uninfected locality by infected persons, infected rats, infected clothes, and possibly by infected goods.

Infected rats probably travel but short distances on foot, and spread the infection to neighbouring villages, or to uninfected parts of an infected town. They also travel concealed in bales of goods, and may thus proceed by train long distances. It is probable that though they may die on the journey, the infected carcase may act for a time as a centre of infection to rats or man at its destination, and by handling the polluted goods an outbreak in man may be set up. A case of this nature occurred in Port Elizabeth, where a European had occasion to unpack a bale of goods at his warehouse after it had come from the docks, where many plague rats had been found. A rat, afterwards proved to have died from plague, was found among the goods, and four days after the man was attacked by plague. The only source of infection at all probable was the handling of these infected goods. Had this bale gone up country it is possible it might have furnished the first indigenous case at its destination. It sometimes happens that the first cases in a locality appear associated with the railway goods' stores in an uninfected place, as at Bangalore, where the early cases in the city were all associated with *employés* and their families engaged in the goods' stores of the Southern Mahratta Railway. The passenger staff and railway passengers were not attacked till later. During the time railway inspection was strictly carried out in all parts of India, a large number of plague cases were detected, in all stages of the disease, from those in the stage of invasion to the moribund and even the dead. I have found them concealed beneath the carriage seat. The importation of a pneumonic case into the confined atmosphere of an Indian home might readily set up an epidemic in an uninfected place. The Indian Plague Commission were of opinion that plague was carried through India from place to place by human agency. According to some the importation of a single case may set up an epidemic among rats in that place, and through them an outbreak among man is started. There is evidence that this does occur sometimes, and at other times the outbreak among rat and man appears to progress side by side. It is noteworthy that on many occasions plague has not been inclined to spread by land; in South Africa the disease has never gained a footing outside the coast towns of Cape Town, Port Elizabeth, and Mossel Bay, and medical inspection has been sufficient to prevent suspected persons travelling inland to infect other parts of the country; a few isolated cases have occurred here and there, but their prompt notification and isolation has prevented the spread of the disease. The small localised outbreaks which have occurred in England and Scotland have also been readily subdued. In India, however, the case is otherwise, and plague has spread by land over most of the Indian Empire.

(*b*) *By Sea.*—The present pandemic prevalence of plague is almost entirely due to its diffusion by sea. In 1894 Southern China and Assyr (Arabia) were the only parts of the world at all likely to infect the rest of the globe. Reference to the geographical distribution of plague, already referred to, for the years since 1894, show the gradual development of plague in Eastern ports, Assyr at first having little influence. The infection of Bombay in 1896, probably from Chinese ports, was shortly followed by the gradual invasion of a considerable portion of India, and now in 1902 the area of infection is still increasing in that country. In 1897 Assyr probably infected Jeddah and Mecca, and from Jeddah, from Bombay, and from the ports of Southern China very many of the countries of the world have now become infected, though in many cases the importation of infection has not resulted in an epidemic at the port into which plague has been introduced. Among the European ports into which plague has been introduced from infected extra-European places may be instanced Marseilles, Genoa, Trieste, Hamburg, Cardiff, London, Plymouth, Hull, Bremen, Naples, Oporto, and Dunkirk, fortunately in most cases without setting up an epidemic.

Plague frequently exhibits a tendency to spread in a country from port to port (Australia and South Africa), or to places upon navigable rivers (Australia and South America). There are, at least, three possible vehicles of spread of plague over sea, viz. infected man, infected rats, and infected goods and clothing.

There appears to be little or no evidence that plague has invaded a country by the aid of infected goods, where evidence of gross contamination by plague rats is absent (a few cases of infection by clothing have been already noted). On the other hand, there is a good deal of evidence that plague rats have carried infection from country to country. The source of infection of Asunçion (Paraguay) is ascribed to this agency. Rice bags from India, it is alleged, were transhipped into a sailing ship, the *Zeir*, in which dead rats were afterwards found, and on board which cases of suspicious illness occurred. From the *Zeir* the rice bags were transhipped into a steamer, the *Centauro*, which called at various Argentine ports on her voyage up the River Plate, and on board which three suspicious deaths occurred among the crew, and on which excessive mortality among rats was observed. A fortnight after the arrival of this ship in Asunçion a large rat epidemic was noticed on the Customs House premises, bacteriological examination confirming the diagnosis of plague. An outbreak of plague in man followed.

The infection of the South African ports is ascribed, as has been said, to infected rats in South American forage which was conveyed in great quantity during the war; the dock *employés* were the first to contract the disease, under conditions already described. Plague in Sydney is supposed to have been introduced from some infected port, the dock rats becoming first affected, and subsequently the town and its inhabitants. Plague rats were also found in the docks at Adelaide, Brisbane, and Melbourne. It is noteworthy that in most plague-infected ports it is the dock *employés* who are first attacked, which would seem to absolve ships' crews and passengers from being the usual carriers of infection, though sometimes cases are detected among sailors at the routine medical examination of the vessel on arrival. The infection seems, therefore, to be conveyed by the ship by some other means than the crew and passengers, and that, it is surmised, is by infected rats and infected goods. We have noted that most of the evidence at our disposal points to infected rats as being the great carriers of infection from country to country. This view is further strengthened by the very frequent association of plague rats in the docks of plague-infected ports; in addition to the Australian and South African ports already referred to, we may instance Alexandria, Port Said, Santos, Rio de Janeiro, San Nicholas, Asunçion, and other South American towns.

While attaching great importance to the importation of the infection of plague by means of the rat, the agency of man as a carrier of infection must not be overlooked. Many instances of ships having human plague cases on board have been detected at their port of arrival. To consider only the cases which have arrived in this country:—In 1896 three cases occurred in London Docks among the crews of steamers from Bombay some days after arrival in port. In 1897 and 1898 two cases occurred in each year during the homeward voyage from India. In 1899 four ships were reported as infected. In 1900 twenty-three ships arrived in English ports with suspicious cases, among whom only four were proved bacteriologically to be plague. In 1901 thirty-three suspected ships arrived, one ship from Alexandria furnishing nine cases of plague (including two infected while upon attendance on the sick in port), another having had cases on the voyage from South America, and another one case from Cape Town, and two others had had cases *en route* from India. In addition a vessel from Smyrna arrived at Bristol with plague-infected rats. During 1902 only eleven ships suspected of being infected by plague arrived, one with a case on board, other four having had cases during the voyage. Four ships had had a rat mortality on board. Only one of these rat epidemics was suspicious of plague, but the bacillus did not react to all the tests for the specific micro-organism of plague. There was, however, a certain amount of similarity between these bacilli. No cases of plague have occurred in Great Britain beyond ship-borne cases, except the Glasgow cases of 1900 and 1901, Liverpool 1901, and two cases (one of which was not bacteriologically confirmed) at Cardiff in the same year, both employed in grain stores in the docks where there was a rat epidemic. It is to be noted that all these places are ports, and the employment of some of the household of the first cases in Glasgow and Liverpool, as has been said, has been traced to the docks, but no source of original infection has been determined.

It is obvious that medical inspection of shipping from infected ports is of great value in keeping plague cases out of the country, and in this we have been very successful; but it would appear, in the light of the experience of other countries, that the infection of the ports of this country may possibly occur by means of plague rats rather than by human agency, and a very much more difficult cause to prevent.

5. Symptomatology and Types

Plague may be divided into the following clinical types:—(1) Bubonic plague; (2) Septicæmic plague; (3) Pneumonic plague; (4) Intestinal plague; (5) *Pestis ambulans*; (6) *Pestis minor*.

It must be recognised that these types are not distinct, and that a patient suffering from bubonic plague may be also suffering from plague septicæmia and pneumonia, *i.e.* cases of a mixed type are not uncommon. The essential characteristic of plague is inflammation of the lymph glands, usually those in the groin, axilla, or neck; it is to these cases the term bubonic plague is applied. In the septicæmic type, the internal lymph glands throughout the body, such as the mesenteric and retro-peritoneal glands, are found to be affected. In the pneumonic type the glands at the root of the lung are frequently implicated. It is doubtful whether there is a distinct intestinal type of plague. *Pestis ambulans* is a mild form of the bubonic type. *Pestis minor* is a mild glandular complaint which may have some relation to plague, as yet ill-determined.

(1) Bubonic Plague.—After an incubative period, commonly from two to five days, the disease sets in with sudden high fever, preceded sometimes by rigors, sometimes in children with convulsions, and sometimes by prodromal symptoms, as headache, chilliness, nausea, vomiting, vague pains in the back, groins, or axilla. The patient rapidly becomes markedly ill.

Examination of the case in its early stages shows great prostration, high fever, swelling or tenderness in the groin, axilla, or neck, giddiness, loss of appetite, nausea, sometimes vomiting and diarrhœa, pains in the head, back, and limbs, restlessness, sleeplessness, and it may be delirium, together with inco-ordination of speech and gait. Injection of the conjunctiva is frequently well marked; the face is at first flushed, becoming pale later, and the expression may be anxious or apathetic. The pulse is rapid, and the respirations may be increased. The tongue is usually coated, with red edges. The signs and symptoms of plague, as they affect the various systems of the body, are as follows:—

Lymphatic System.—In this system we find the characteristic plague lesions, buboes being present in about three-quarters of the cases, in some epidemics a greater proportion, though in others few of the cases may show enlarged glands. In a short time, varying from a few hours to two days, the characteristic bubo makes its appearance. There is first a mere tenderness in the groin, axilla, or neck—it may be only upon pressure. Then a slight fulness and redness appears, with increasing tenderness. It is not uncommon to find one or more enlarged glands quite distinct from one another. Later, with periglandular effusion, they become agglutinated together. The term bubo does not mean an inflamed gland, but one or more glands matted together, along with the periglandular infiltration.

These changes may succeed one another with great rapidity, a surprising difference being manifested in but a few hours. The swelling may reach the size of an orange, or a man's fist, or even larger. Pain on palpation, as a rule, is exquisite; the neighbourhood of the glands implicated reveals a considerable amount of œdema, so that the gland itself can be made out sometimes only on deep pressure. The patient often lies with a flexed limb to relieve pressure on the bubo, his attitude giving sometimes a hint as to the site of the glands affected. Deep palpation in the iliac region will often reveal the presence of inflamed glands, which are especially associated with inguinal and femoral cases; occasionally these iliac glands may be the only ones implicated, and may give rise to some difficulty in diagnosis, as sometimes they cause little pain till they are palpated. The epitrochlear and popliteal glands are occasionally affected, but nearly always in association with buboes elsewhere. As has already been stated, the groin is the commonest site for the bubo, then come in order of frequency the axilla, neck (cervical, parotid, and submaxillary glands), epitrochlear and popliteal glands. This probably depends on the mode of entry of the disease into the body, *i.e.* through abraded skin surfaces, for there is a relation between the extent of the area of skin surface draining into the various sets of glands and the frequency with which these glands are affected, as has already been described. Frequently more than one region of the body shows buboes, and in each region affected there is usually more than one gland implicated.

In this disease some part or other of the lymphatic system is always affected, though often this cannot be discovered until a post-mortem examination has been made. In the bubonic type the bubo is always evident, though in the rarer cases of pelvic buboes the affected glands may be overlooked unless due care be taken.

The œdema which is always present in the periglandular tissues may extend over a wide area, causing considerable swelling over the thighs and lower part of the abdomen or over the sternum and shoulder blades. The trachea and larynx may be pressed upon, causing dyspnœa. Hæmorrhages may discolour the skin over a considerable area.

As the degree of coma of the patient increases, the pain produced on palpation may not be so apparent, though, even where considerable coma is present, palpation of the bubo will produce evident pain and expostulation, or it may be merely a groan.

If the patient lives, the buboes resolve or suppurate, and this is frequently very prolonged. Suppuration usually occurs in the second week of the disease; sometimes it may be delayed for a considerable time. The whole gland or glands and surrounding tissues may slough *en masse,* leaving a large deep ulcer, which finally granulates up. Often a very obstinate sinus persists for a long time. Cases sometimes occur where gland after gland in different parts of the body become involved and break down, the process going on for several months, and occasionally cases occur where glands break down after discharge from hospital; these are rare, but one or two such cases occurred in Cape Town during the recent epidemic.

The temperature has sometimes by the second day attained its maximum; at other times it rises gradually till the third or fourth day, when it frequently falls a little, and in mild cases it begins to descend to the normal. Generally, however, the temperature rises again till the fifth or seventh day, when it descends by lysis to normal. This may be followed by an intermittent fever caused by septic absorption. A fresh elevation in temperature may occur from fresh glands becoming involved, or from secondary pneumonia. Frequently before death the temperature may attain a great height, such as 108° F. or even higher, and continue rising after death to over 110° F. when taken in the rectum. Sometimes the temperature just before death is subnormal.

Respiratory System.—The respirations are increased, being usually thirty to forty per minute. Besides plague pneumonia, which may be primary or secondary, and which is described later, bronchitic symptoms and œdema of the lung may supervene. Lung complications in the bubonic type vary in frequency in the different epidemics.

Circulatory System.—In the early stages of the disease the pulse is full and dicrotic. Even in very mild cases the rapidity of the pulse is increased and may afford considerable diagnostic assistance in abnormal cases. It may also give information that the patient's condition is more serious than would otherwise be imagined. Patients very ill, and sometimes within a few hours of death, may be able to walk about; examination of the pulse at once reveals their critical condition.

The heart may become dilated, the apex beat may be diffused, and murmurs may be audible at the apex and in the pulmonary area. There is great tendency to heart failure in this disease, and it may come on very suddenly without any warning. There is generally leucocytosis and sometimes diminution in the number of red blood corpuscles.

Alimentary System.—The tongue is usually coated at first and has an appearance resembling chalk or mother-of-pearl; the edges are clean and red. Later the tongue becomes dry and cracked and of a brown colour. It is not uncommon for patients to die with quite a moist tongue. The teeth, lips, and nostrils become crusted, and the lips dry and shrivelled. Nausea and vomiting are common at the onset and for the first day or two of the disease. Constipation is common at the beginning, followed by diarrhœa, the stools sometimes containing blood. There may be abdominal tenderness and distension. Thirst is usually a marked symptom.

The liver and spleen are enlarged and are usually tender, particularly the spleen.

The Urinary System.—The secretion of urine is diminished and may be suppressed, associated with lumbar pains. Retention of urine is not uncommon, and the catheter may have to be employed. The urine is of a dark colour, strongly acid, high specific gravity, and contains urates and sometimes true and nucleo-albumin. Microscopically, granular, hyaline, and rarely fatty tube casts may be found, together with blood corpuscles. The Austrian Plague Commission found that the chlorides were in almost all cases markedly diminished.

The Nervous System.—This system is especially implicated in plague. Every degree of mental disturbance may be met with; apathy, anxiety, delirium of varying degrees, or acute mania may be present, and suicidal and homicidal impulses may supervene. The mind is nearly always more or less affected, sometimes it is merely clouded, or memory is defective and the attention frequently wanders; sleeplessness is a troublesome symptom. Inco-ordination of speech is usually well marked, the patient often knowing what he wants to say, but has difficulty in articulating it. Inco-ordination of the muscles is often well marked; twitching, picking at the bed-clothes, tonic and clonic spasms may be present. The speech is usually thick and the gait staggering, and these, together with the conjunctival injection, may present a picture suggestive of alcoholic excess.

At times, even in cases where death is imminent, the mind is but little affected and the patient painfully realises his critical condition. Restlessness and purposeless movements are of frequent occurrence among those attacked by plague, leading them to make train journeys and expeditions seemingly without an object; a part of this, however, is explicable, especially in native races, by the fear of being discovered as a plague patient, or to the promptings of friends. Nervous sequelæ may follow plague, such as motor paralysis and insanity.

Cutaneous System.—The skin during the high fever is hot and dry, followed by perspiration on the fall in temperature. Primary and secondary plague boils, pustules, and carbuncles may occur. The primary lesions occur at the point of inoculation of the disease, beginning as a small papule and going on to pustulation. The *bacillus pestis* may sometimes be recovered from the pustule in nearly pure culture. There is usually considerable surrounding redness, and it may be lymphangitis between the pustule and the nearest lymph gland; vesicles, pustules, and furuncles may develop along this track. Occasionally a type of plague has been described, limited to the skin, under the name "Skin Plague or Pustular Plague." The general symptoms resemble bubonic plague, but are milder, and the termination, apart from the local skin destruction, is more frequently favourable; the carbuncles usually take an abortive course and dry up, unless other local or general symptoms appear (Scheube).

Secondary plague pustules, boils, and carbuncles are sometimes met with, usually during the first week of the disease. Accompanied by a feeling of heat, stinging or itching pains, there appears a small brown spot over or round a bubo, surrounded by redness and induration. A small vesicle develops with a dark red margin, which becomes larger, and may reach the size of a Brazil nut. The base of the vesicle becomes a black slough, which in time becomes a black ulcer of crater-like formation. In process of time the ulcer heals by granulation (Scheube). Similar sloughs may be produced by native applications to the bubo, as occurs in India. Sometimes more extensive carbuncle formation occurs with necrosis and loss of tissue, so that a large extent of muscle may be laid bare, and sometimes hæmorrhages may supervene.

Petechiæ may be present, commonly on the neck, chest, and extremities. They may occur as small purpuric spots or partly punctiform and partly wheal-like, or large red, black, or livid hæmorrhages. The incidence of such cutaneous affections appears to vary very much in different epidemics. Papular rashes are sometimes met with, distributed all over the body. Sometimes these are said to go on to pustulation. Rashes have from time to time been described, which have a typhus-like, morbilliform, erythematous, urticarial, or sudaminous character, but they are rare. Typhus-like rashes have been described by Hossack, in Calcutta (*Journal Trop. Med.*, 1st January 1901), though in his cases drugs may have had something to do with the causation of the rash.

Hæmorrhages.—Bleeding may occur from the nose, mouth, lungs, stomach, rectum, kidneys, and female genital organs, usually at the height of the disease. Abortion and premature labour frequently occur, and result almost invariably in death; cases of recovery are, however, upon record.

Eye affections may occur early, even on the first or second day of the disease, such as parenchymatous keratitis of one or both eyes, leading to iridocyclitis usually, and sometimes to complete suppuration of the eyes.

Termination.—Death may occur at any stage of the disease, but most frequently on the third to fifth day, so that after a week the prognosis becomes more favourable. There are well-marked fulminant cases (*pestis fulminans* or *siderans*) where the patient has been able to attend to his work most of the day apparently in good health, and on going home has been attacked and died of plague the same evening. Although it is true that Europeans, as a rule, do not suffer so severely from plague, I have seen some cases of this fulminant type among them; in some instances the disease ran its course in six or eight hours. In view of such cases, sudden deaths during a plague epidemic should be regarded with suspicion until the diagnosis can be satisfactorily cleared up.

In plague the cause of death is usually heart failure, which may be very sudden and unexpected, or ushered in with a small, frequent, weak, and irregular pulse, coldness of the peripheral parts of the body, high temperature, and sometimes cyanosis or lividity of the face. Other causes of death may be asphyxia from extensive inflammation and infiltration in the neighbourhood of the throat, or hæmorrhages from the lungs, or from ulceration into large blood-vessels elsewhere. Death may occur from meningitis, pyæmia, septicæmia, pneumonia, or marasmus. Patients have been known to become maniacal, and to have died violent deaths by jumping through windows, or on board ship through port-holes into the sea, and in other like ways. In favourable cases the disease passes on slowly to convalescence, through remission of the severer symptoms, between the first and second weeks. Progress may be slow, and the incised bubo may sometimes take a long time to heal. Some considerable time may elapse before the patient regains his normal health. Cases suffering slightly from pulmonary tuberculosis may rapidly die from an acute form of the disease. Bubonic cases which have not suppurated will, in general, require to remain in hospital from five to eight weeks. In those in which suppuration has occurred the incised bubo, in a number of cases, heals fairly readily, and complete convalescence may not be unduly protracted. In some cases three or four months may occasionally be necessary before a firm cicatrix is established or before glands in different parts of the body cease to break down. It is necessary to consider a gland infectious as long as it is discharging, though probably after some weeks it no longer contains the specific organisms.

(2) SEPTICÆMIC PLAGUE.—This form of plague consists of a rapidly fatal septicæmia, terminating in a few hours or a day or two in primary cases. Secondary septicæmia or pyæmia may supervene in bubonic cases, and are common causes of death. For statistical purposes, however, these secondary cases are not regarded as cases of septicæmic plague, but are classified as bubonic. In this connection it may be noted that although it is convenient for purposes of description and classification to divide plague into several types, in practice it is common to meet with mixed forms of the disease.

The term septicæmic plague may therefore be confined to a primary septicæmia, without external buboes. The onset is frequently sudden, prostration is extreme, the patient may lie in a collapsed or comatose condition, he may be delirious, and sometimes breathes with a groaning respiration, or only a groan may be elicited on interrogation. On examination a weak, irregular pulse, and sometimes an enlarged spleen and hæmorrhages from the mouth, rectum, or female genital organs may be discovered; and in females it may be found that the patient has aborted or been prematurely delivered, the so-called "puerperal" form of plague. The temperature is usually hyperpyrexic or it may be apyrexic. Without a bacteriological examination diagnosis is uncertain, but in blood taken from the peripheral circulation the specific bacillus can often be discovered in films or upon culture.

Pestis fulminans and siderans belong to this type of the disease. The termination is fatal in practically all cases.

(3) PNEUMONIC PLAGUE.—Plague pneumonia may be primary or it may be secondary to an attack of a bubonic type.

Childe first noted this primary plague pneumonia in Bombay, though plague epidemics with lung symptoms are mentioned in some of the early writings upon this disease. Commencing with rigors, high temperature, headache, pains in the limbs, and giddiness, pneumonia develops with pains in the chest, dyspnœa, cough, expectoration, and accelerated breathing.

The physical signs are often obscure and evanescent. There may be dulness over one or more lobes, or it may not be definitely made out. Moist sounds are usually heard, and occasionally bronchitic râles. The fever is high, intermittent, and often irregular, the pulse frequent and weak. Delirium is a marked feature of plague pneumonia, passing on to coma as death approaches. As points in the differential diagnosis of this form of the disease, the prostration is very marked and out of proportion to the physical signs. The pulse and respirations are rapid, but there is not the same disproportion in their ratio as is observed in ordinary pneumonia. There may be tenderness in the groins, axilla, or neck, and frequently enlargement of the spleen. It is stated that *herpes labialis* is rarely or never present.

In the early stages the sputum may be thick and tenacious, and slightly tinged with blood; it later becomes a watery blood-stained secretion, sometimes consisting of almost pure blood; it wells up in enormous quantities and is generally laden with plague bacilli, sometimes in nearly pure culture. The rusty sputum of ordinary pneumonia is seldom met with in this form of the disease. The Russian Plague Commission state that cough and expectoration may be entirely absent.

The disease has in the great majority of cases a fatal termination in three or four days from œdema of the lung. Sometimes the disease takes the form of what seems to be a simple bronchitis, suddenly terminating in death. In certain epidemics, cases of plague pneumonia are not reported to have occurred. In the 1894 outbreak in Hong Kong, this type was either not present or, what is more likely, was not recognised, Childe at that time not having described this form of the disease. Sometimes an outbreak consists almost entirely of pneumonic cases.

(4) INTESTINAL PLAGUE.—It is doubtful whether this should be considered to be a distinct type of plague, but it was described by Wilm in Hong Kong, 1896. In it no buboes occurred, but all the symptoms were referable to the intestinal tract, with vomiting, diarrhœa, and passage of bloody slime per rectum. It has not been observed in Bombay. Personally I have only observed intestinal symptoms in those cases which have also been suffering from one of the other well-marked types of plague.

(5) PESTIS AMBULANS.—This term should be reserved for those cases of true plague in which the symptoms and constitutional disturbances are mild. There may be pain in several groups of glands and slight fulness or swellings in the groin, axilla, or neck, which swellings ultimately resolve or suppurate. There is some prostration, a varying amount of fever, some conjunctival injection, and may be some inco-ordination of speech; the tongue has a creamy coat with clean edges. The characteristics of this form of the disease are therefore those of a mild bubonic type of plague, not readily recognised unless looked for with care, and apt to be mistaken for mumps, syphilis, tubercular glands, or the results of strains and injuries. It is stated that such ambulatory cases occasionally terminate suddenly and unexpectedly in death, though I have not met with such instances.

In chronic cases of this type suppuration may be prolonged. These ambulant cases are regarded by many authorities as being a great source of danger to the community by going about with impunity spreading the disease. There is not much evidence in favour of this view.

(6) PESTIS MINOR.—This term has been applied to a mild epidemic disease characterised by some fever and the formation of buboes, usually in the groin, which after a time resolve or suppurate. In some cases epidemics of this kind have preceded by a few months or years epidemics of true plague, such as happened in Mesopotamia (1876-77), Astrakhan (1877), Singapore and Straits Settlements, and the south coast of China (1893). *Pestis minor* was also reported to be present in Calcutta in 1896. Epidemics of this disease have been observed without true plague following them, and true plague epidemics are usually, as far as is known, not

preceded by outbreaks of *pestis minor.* It is at present uncertain whether such epidemics are due to the *bacillus pestis,* a question which can only be cleared up by bacteriological investigation. There is no doubt that there are epidemics or groups of cases of non-venereal glandular disease, but they may be due to several causes, some perhaps being due to the plague bacillus. In these glandular fevers, or so-called "climatic buboes," the glands and skin over them often break down. The term *pestis minor* has been misapplied to *pestis ambulans,* but it is better to keep them distinct.

Sequelæ.—In addition to long-continued weakness which may follow an attack of plague, rendering mental and physical exertion an impossibility for some time, the following sequelæ may be mentioned:—Long-continued suppuration of glands, boils, and carbuncles, joint inflammations, especially the knee joints, paralysis of various kinds (face, muscles of the eye, palate, larynx, etc., hemiplegia, paraplegia), ataxia, mental disturbances, loss of speech, deafness in one or both ears, or the sight may be affected by intraocular changes; *i.e.* the commonest sequelæ are nervous or suppurative.

Incubative Period.—The number of cases in which the incubative period can be definitely settled is small, but such as they are seem sufficiently conclusive. The Indian Plague Commission found in 13 cases of accidental inoculation, in the course of post-mortem work, the incubative period was from one to three days, and in 16 cases in which the occasion of coming into contact with an infected person was known the period was from eight hours to five days; the average period in both series was under three days. This coincides with the experience of those who have been much engaged on plague work, the incubative period rarely exceeding five days. Perhaps cases of prolonged incubation do occur, but it is often difficult to entirely eliminate other sources of infection in such cases. For practical purposes seven days can be regarded as the outside limit in nearly all cases, and two to four days as the incubative period in the great majority of instances. Preventive measures framed on a fourteen or even twelve days' observation of "contacts" appear to impose needless restrictions.

Mortality.—In many outbreaks it is impossible to arrive at a true mortality of the epidemic on account of the concealment of cases generally practised among native races. In some parts of India the plague mortality has been described as the difference between the actual mortality and the average mortality of non-epidemic years, a method which no doubt, after making certain deductions, gives a truer idea of the plague mortality than the bare record of the reported deaths from this disease. Similarly, among native races it is difficult to get an idea of the true case mortality of a plague epidemic, as no doubt many mild cases escape recognition and many plague deaths are ascribed to other causes. For this reason the appalling case mortality in Hong Kong may not represent the true facts of the case, as a very large number of the cases were dead when discovered. From 1898 to the middle of 1901 the percentage of dead bodies found among the total number of cases reported were respectively 36, 40, 37·1, and 21·7 per cent. During the first three years of plague in India, from 1896 to 1899, the Indian Plague Commission estimate the mortality at 430,500. In some villages in Dharwar the number of plague deaths ranged from 22 to 25 per cent of the entire population, a severity paralleled by that of the Black Death of the fourteenth century. There is no doubt that certain races suffer more severely during an epidemic of this disease, both as regards susceptibility to attack and case mortality, partly due to their insanitary surroundings and consequent weakened resisting powers, also to their labouring in infected localities, native habits of life, and lack of early hospital treatment.

In modern plague epidemics of any magnitude, the hospital-treated European cases always show a more favourable result than native cases treated under similar conditions. In Sydney (1900), out of 293 European cases the case mortality was 32·4 per cent, and out of 10 Chinese 8 died. In South Africa (1901 to the early part of 1902), among 221 Europeans 33·9 per cent died, and among 450 coloured people (those of partly European blood, more or less remote) 56·7 per cent died. Among 205 natives (including Africans, Malays, Chinese, and Indians) the death-rate was 44·4 per cent.

The case mortality varies also with the different phases of the epidemic. In the 293 Sydney European cases, we have the following figures :—

20th January to 12th April 1900, 100 European cases, fatality 37 per cent.
12th April to 9th May „ „ „ 37 „
9th May to 9th August 93 „ „ 23 „

In Sydney the disease was at its full virulence from the beginning, and became milder towards the close of the epidemic.

The Indian Plague Commission also found a variation in mortality with the phase of the epidemic. A study of the curve of incidence and curve of case mortality in the case of Bombay city shows that at the beginning and end of an epidemic the number of cases and the case mortality of these is lowest, both curves rising together to a maximum and falling again. In Bombay Presidency and native states connected with it, from September 1896 to 1st January 1900 there were 392,285 *reported* cases, with 308,140 *reported* deaths (excluding Europeans), a case mortality of 78·53 per cent, varying from 83·7 to 59·3 per cent during this period. The figures are certainly very inaccurate, as all statistics must be from countries like India and China, and probably do not give a true idea of the case mortality.

The influence of sex on mortality does not appear to be marked in India or South Africa. Out of 5294 Indian cases collected by the Commission the male case mortality was 71·15 per cent, the female 69·37 per cent. In South Africa, out of 638 males 47 per cent died, and out of 238 females 50·8 per cent. The fatal character of plague in pregnant women has an influence in this connection.

6. Morbid Anatomy and Bacteriology

(1) *Morbid Anatomy.*—The pathological features of plague are congestion of the organs, tendency to hæmorrhages, inflammation and surrounding œdema of the lymphatic glands, with the occurrence of the *bacillus pestis* in the glands and usually also in the internal organs.

(*a*) *External Appearances.*—The body is usually well nourished and *rigor mortis* may be well marked. Examination of the groin, axilla, or neck may show buboes surrounded by considerable œdema. Petechiæ are frequently observed on the chest and limbs. Phlyctenules may be present on the limb upon which the bubo is present.

(*b*) *Internal Appearances—Lymphatic System.*—The entire lymphatic glandular system of the body is frequently involved, even in those cases which show no external bubo. On section of the skin overlying a bubo, a copious infiltration of an œdematous jelly-like fluid and hæmorrhages are met with in the periglandular tissues. The glands on section appear dark red or blackish in colour, very juicy, often soft and pulpy; abscess formation or necrosis of the gland tissue may be found. The bubo may consist of several glands more or less matted together. Chains of glands similarly affected may be found leading from the bubo, and frequently such chains are found leading from the groin to the sacral and lumbar glands, and from the axilla to the mediastinal glands. These secondarily affected glands may show less change than the original bubo. The glands and periglandular infiltration are found to be swarming with plague bacilli.

In pneumonic plague it is common to find the bronchial glands involved, and in septicæmic plague the lymphatic glands in various parts of the body are found to be implicated.

Hæmorrhages are a characteristic feature in the pathology of this disease. They may occur all over the body; in addition to the lymph glands already referred to, they may occur on the surface and in the substance of most of the organs of the body, the commonest sites being the lungs, heart, liver, spleen, and kidneys. The colour varies from a bright red to a reddish black or black, and the size from a minute pin point to several inches in extent. In pneumonic plague the lungs nearly always show these hæmorrhages, extending inwards from the surface. Hæmorrhages may also be found in the skin.

Brain, Meninges, and Spinal Cord.—These are usually congested and may show hæmorrhages. A serous or sero-purulent exudate laden with plague bacilli may be found on the pia mater, especially along the vessels, and the ventricular fluid may be increased. The substance of the brain, spinal cord, and nerves present a normal appearance.

Lungs and Pleura.—The pleura may show engorgement, and hæmorrhages and exudates, clear or blood-stained, may occur in the pleural cavity.

The lungs are generally congested and œdematous, especially the lower lobes. Hæmorrhages and hæmorrhagic infarcts are common, and the thoracic glands may be involved.

In plague pneumonia the typical appearance is that of a confluent lobular pneumonia with scattered irregular patches of varying size from a bean to an egg, grey or red in colour, surrounded by dark red hæmorrhagic areas and œdema. Pleurisy may be present over the surface of these patches. The pneumonic patches may become necrotic. In some post-mortems all one sees may be œdema, and no patches may be made out. In others a whole lobe may be consolidated. The bronchial tubes contain frothy sero-sanguineous fluid, and their mucous membrane may be congested. Crowds of plague bacilli are found in smears from the pneumonic patches and infiltration. The bronchial glands are commonly involved.

The heart is usually dilated, especially the right ventricle. The heart muscle is frequently pale, and may show parenchymatous, cloudy, or fatty degeneration. The visceral layer of the pericardium often shows hæmorrhages of various sizes, especially between the auricles and ventricles. Subendocardial hæmorrhages may be found, and sometimes there are hæmorrhages into the muscle substance itself.

Peritoneum.—Subperitoneal hæmorrhages are common beneath the parietal layer, and upon most of the viscera. Retroperitoneal extravasation of blood associated with inflamed retroperitoneal glands may be found. Extensive extravasations of blood may be found in the omentum and mesentery, particularly in septicæmic plague.

The liver is usually large and hyperæmic. It may be pale and soft, showing parenchymatous degeneration. Necrotic abscess-like foci may be found surrounded by a hæmorrhagic area. Under the capsule of the liver hæmorrhages are frequent, and some authorities state that hæmorrhages on the gall bladder are very common. Cholecystitis and pericholecystitis have been noted.

The spleen is always enlarged and congested, the colour of its substance being usually very dark, and it is generally soft and is readily broken down. Hæmorrhages under its capsule are of frequent occurrence.

Stomach and intestines frequently show petechiæ and ecchymoses in their mucous membranes. The solitary follicles and Peyer's patches are often swollen.

The kidneys are often swollen and congested, the cortical substance enlarged, and the parenchyma shows cloudy or fatty degeneration. Hæmorrhages, subcapsular or in the pelvis of the kidney, may be seen, or there may be hæmorrhagic infiltration round the organ.

The bladder may contain bloody urine, and its mucous membrane may be ecchymosed.

The Uterus and Fallopian tubes may show hæmorrhages in their mucous membranes. The uterus in cases of plague in pregnant women will usually show signs of recent abortion or delivery. These organs should be examined in cases of sudden death in women without a satisfactory medical history.

Post-mortem Appearances in Septicœmic Plague.—The changes are as just described in the internal organs of the body. Hæmorrhages into these organs, and inflammation of the lymphatic glands in the thorax and abdomen, are commonly met with. From nearly every organ the *bacillus pestis* may be recovered.

(2) *Bacteriology.*—The plague bacillus was discovered by Yersin in 1894 during the Hong Kong outbreak. A bacillus discovered by Kitasato in the same epidemic has been supposed to be identical with that of Yersin, but Kitasato himself has now admitted that Yersin's bacillus is the specific organism of this disease (Report on Plague, *Journal Bacteriologicus Japonis*, December 1899). It is a short oval bacillus with round or square cut ends, occurring singly or in dumb-bells, and occasionally in chains. It is sometimes surrounded by a capsule. In fresh specimens it frequently occurs in pairs as a diplo-bacillus. It is not motile, nor does it form spores. Its size ranges from 1·5 to 2μ, and is $\cdot 7\mu$ in breadth, as average measurements, but it may be longer or shorter than this, and its size is indeed very variable. Mervyn Gordon and others have succeeded in demonstrating the existence of flagellæ.

The bacillus stains easily with any of the ordinary aniline dyes, Löffler's methylene blue (concentrated alcoholic solution of methylene blue, 30 c.c.; potassium hydrate solution (1 in 10,000), 100 c.c.), or very dilute carbol fuchsin being convenient stains. It is decolourised by Gram's method. The bacillus in fresh specimens generally shows a marked tendency, though not always, to a *bipolar stain*, the ends taking up the dye more readily than the middle. Neisser's double stain (glacial acetic acid, methylene blue, and Bismarck brown) also causes this bipolar arrangement to be exhibited. In actively growing cultures the polar stain is nearly always absent.

The bacillus may be conveniently demonstrated from post-mortem specimens or from punctures of suspected glands by making cover-glass preparations, drying, fixing with a mixture of equal parts of ether and absolute alcohol, and staining for a few minutes with methylene blue. After washing, drying, and mounting the specimen may be examined, and the above appearances observed. In chronic cases, and in those in which the bubo has been present a few weeks, very few or no plague bacilli may be visible in such films.

The organism is ærobic, but it can grow, though less readily, under anærobic conditions. In cultures the organism grows readily on all the ordinary laboratory media, forming white, moist, transparent, and iridescent colonies on blood serum at 37° C. in twenty-four to forty-eight hours. Upon agar the colonies are small and round, almost translucent by transmitted and white by reflected light; on contact with a platinum needle they exhibit a characteristic, tenacious, slimy quality, and are not very firmly connected with the culture medium (German Plague Commission). In stab cultures in gelatine it grows slowly along the track of the needle, and the medium is not liquefied. A rapid grayish-white surface growth occurs on glycerine agar. A characteristic growth occurs in bouillon, a white granular deposit growing at the bottom and sides of the tubes, the culture fluid appearing clear. The characteristic "*stalactite*" *growth* occurs in faintly akaline or neutral peptone broth, to which a few drops of olive, cocoanut, or linseed oil or *ghee* have been added, stalactites of growth hanging from the floating oil-drops (Haffkine). The flask must be kept absolutely at rest at a temperature of 25° to 30° C., when after several days this phenomenon gradually takes place. This is the method made use of in the preparation of Haffkine's prophylactic. After several subcultures this appearance may cease to be produced, but passage through a susceptible animal will restore it, or it may spontaneously reappear (Klein).

In sugar-containing media there is no fermentation or gas production.

In old cultures upon agar and bouillon, involution forms of the organism are found, which show great variety in shape, sometimes a long slender bacillus, segmented and vacuolated, at other times swollen and pear-shaped. These forms stain badly. On agar, to which 2·5 to 3·5 per cent salt solution has been added, Hankin and Leumann found these involution forms appeared in twenty-four hours at 37° C.

Viability of the Plague Bacillus.—The *bacillus pestis* is killed by heating for ten minutes at 62° to 65° C. It loses its virulence by drying, and requires both warmth and moisture for the maintenance of its virulence. The bacillus can, however, grow on media at a low temperature for a long period.

Corrosive sublimate, 1 in 1000, kills the organism instantaneously; carbolic acid and lysol, 1 per cent, in ten minutes; sulphuric acid, 1 in 1000, in five minutes.

The German Plague Commission stated that the longest time the bacilli in infected material, such as lint, wadding, etc., remained active was eight days. Sputum from pneumonic cases, kept in a vessel plugged with cotton wool, was no longer virulent after sixteen days. In ordinary drinking water the bacilli die in three days, in sterilised water in eight days, and in sterilised bilge water in five days. In direct sunlight the organism dies in three or four hours. Different observers have, however, arrived at very different results in regard to the action of heat, cold, disinfectants, etc., upon the plague bacillus, dependent partly upon the different climatic conditions under which they were working, and partly also upon the varying degrees of virulence of the bacillus.

The Virulence of the Organism.—This varies in culture and in nature very much, being rapidly lost on artificial media. Its virulence can be exalted by passing through certain animals. Gilbruth has found that by inoculating rats and guinea-pigs with cultures of non-virulent or slightly virulent plague bacilli mixed with a streptococcus or the diphtheria bacillus, the animal rapidly died with the post-mortem signs of plague.

Occurrence of the Bacillus in the Body.—The plague bacillus is found in the buboes in large quantities, a smear from the cut surface of the bubo or material obtained from a puncture frequently showing large numbers of the bacilli, which are also found in the œdematous fluid surrounding the inflamed gland. The smear on staining with appropriate methods shows pus corpuscles, cell debris, blood corpuscles, and micro-organisms. During life, except in moribund cases, it is little use examining smears of blood obtained from the peripheral circulation. During the last twenty-four hours of life, when septicæmia has supervened, blood taken from the ear or finger may show plague bacilli.

In pneumonic cases smears from the sputum will generally reveal the bacillus almost in pure culture. It may also be found in the papule or pustule which formed the original point of entry of the bacillus into the system. Post-mortem smears from most of the internal organs, particularly the liver and spleen, show the organism.

Bacteriological Examination of Suspected Material.—After examination of films of the suspected material, if numerous plague-like bacilli are visible, animals (white rats or guinea-pigs) may be directly inoculated. If these bacilli are scanty, it is preferable to make surface cultivations upon agar, and after twenty-four or thirty-six hours, or after making another subculture if necessary, to inoculate a susceptible animal with some of the growth. Intraperitoneal injection of a guinea-pig will produce death or a dying condition in twenty-four hours, with congestion of the peritoneum and viscera, and a characteristic exudation in the peritoneal cavity, grey, turbid, and viscid in character, and containing numerous plague bacilli (Klein, *Public Health*, December 1900).

Subcutaneous injection into the groin of a guinea-pig or rat produces enlargement of the inguinal glands in twenty-four hours, and usually death in forty-eight to seventy-two hours.

Post-mortem Appearances in Plague-infected Animals.—The appearances in naturally infected rats, mice, and cats are much the same. There is general congestion, œdema, and minute hæmorrhages under the skin and into various viscera, and commonly enlargement of lymphatic glands in different situations, with or without pneumonia.

7. Diagnosis

(1) *Early Recognition of the Disease in a Locality.*—In most towns or places which become plague infected there is well-nigh invariably a section of the press and a large body of the public who most strenuously deny the existence of the disease within their midst, and who place every obstacle within their power in the way of those who are combating the epidemic. This obstruction on the part of the public has been well marked in India, Egypt, and South Africa; in the latter instance not only among the natives and coloured people, in whom ignorance is to be expected, but also among educated Europeans. This attitude is not merely interesting to note, but it is also of importance to recognise, and to expect in future plague epidemics, wherever they may occur, though in this country it is to be expected public obstruction would be slight.

In the early days of an epidemic the only evidence upon which an absolute diagnosis of plague is justified is that of the bacteriologist. Although he can give an opinion on merely staining smears obtained from the patient, he cannot give an absolute diagnosis for three or four days, when his animal experiments are completed. During this period, however, the public health authority has to take precautionary measures, and as far as isolation goes to act as if this suspected case were genuine plague.

The occurrence of two or three cases of pneumonia in the same house or among those visiting it, or several sudden deaths in a neighbourhood under circumstances where association of these persons with one another is known, should cause suspicion as to the presence of some epidemic disease, possibly plague. An increase in the number of deaths in a locality, especially an undue number of certificates of pneumonia, heart disease, and puerperal fever, may become a suspicious circumstance. The occurrence of any illness in a locality in which rats are known to be dying should be looked upon with suspicion until plague can be definitely excluded. Convulsions among children with speedy death may be a manifestation of plague.

(2) *Diagnosis.*—On the occurrence of a suspicious case of glandular fever

after noting the presence or absence of symptoms already described as present in plague, it will be necessary, with antiseptic precautions, to puncture the gland for bacteriological examination. This may be conveniently done by the following procedure:—

(*a*) Wash the skin over the bubo with soap and water, then freely with alcohol. Introduce the needle of a sterilised hypodermic or antitoxin syringe into the periglandular tissue or the substance of the gland and draw off some fluid. It may be necessary to steady the gland, and very little fluid may be obtainable.

(*b*) Make cover-glass smears from the fluid drawn off, and allow them to dry in the air. Fix the films by passing rapidly through the flame of a Bunsen burner or spirit lamp three or four times.

(*c*) The smears can then be stained, as already described, or transmitted to the bacteriologist by placing them in a small box well padded with cotton wool.

(*d*) Some of the fluid should also be sent to the bacteriologist, or cultures made directly at the bed-side.

The bacteriologist then makes microscopic, cultural, and inoculation experiments, and a diagnosis is arrived at.

During the course of an epidemic such precautions are unnecessary, and a history of exposure to infection (where obtainable) and a general examination of the patient are usually sufficient. The chief points of importance are—sudden onset, prostration, fever, headache, rapid pulse, the coated tongue with red edges, vomiting, giddiness, thickness and hesitancy in speech, injection of the conjunctivæ, staggering gait, and glandular tenderness. Cases of *pestis ambulans* are difficult to diagnose, and the glands should be punctured where possible. Failure to recover the bacillus does not, however, put plague out of court.

Pneumonic plague can be diagnosed from the prostration and illness out of proportion to the lung changes which are found, the absence of the respiration-pulse ratio in ordinary, but not so markedly absent in plague pneumonia, and the presence of the specific bacillus in the sputum.

Septicæmic plague can only be absolutely diagnosed from an examination of the blood, which usually shows the bacillus in this type of the disease. During the course of an epidemic of plague, especially among races who do not readily consult qualified medical men during their illness, post-mortem examinations should be made wherever possible in cases of sudden death, or if otherwise suspicious.

Scheube states that the serum agglutinative reaction (equivalent to the Widal reaction for typhoid) is constantly absent in the early stages of the disease, where it would be of special value, and though present in convalescence it cannot be regarded as of any diagnostic help. It has, however, been employed to test suspicious bacilli.

(3) *Differential Diagnosis.*—This may best be considered under the headings of diseases with and without glandular swellings.

(*a*) *Diseases with Glandular Swellings.*—*Results of strains and injuries* are frequent reasons advanced, especially among native races. In ordinary cases of plague the severe nature of the attack points to some acute fever. Milder cases may present more difficulty, but when in doubt the gland should be punctured and the fluid bacteriologically examined. Although the patient may be able to point to a wound on a limb as a cause of his inflamed gland, it must be remembered that the infection of plague may have entered through this wound. In plague the patient feels very ill before the bubo appears.

Diphtheria and tonsillitis with cervical swellings have been confused with plague, from omitting to carefully examine the condition of the throat. Such examination should always be carried out in cases with swellings in the neck.

Syphilis, gonorrhœa and sores on the penis may be the cause of the bubo, but examination of the patient clears up the diagnosis. Plague may, however, occur together with these diseases. The hardness of the glands and absence of tenderness in syphilis, and the fever and severe constitutional symptoms in plague distinguishes these diseases. A sore under the prepuce may cause inflamed glands in the groin.

Chronic tubercular glands may be mistaken for plague, but the history, if reliable, is sufficient to distinguish such cases.

Mumps may cause difficulty in diagnosis, but in mumps the bilateral swelling, the metastatic inflammation of the testicle, which however occurs late in the disease, the comparatively trivial nature of the disease in children, and the low temperature, and in plague the exquisite tenderness of the gland, the severe nature of the disease and other symptoms already described should be sufficient to distinguish them. In plague the parotid gland is not commonly involved, and when it is, the disease is generally very severe, and there is very considerable infiltration of the surrounding tissues. Double parotitis in plague is rare. Cases of mumps do, however, occur with intense prostration and delirium, and mild cases of plague with enlargement in the parotid region. These cases cause difficulty and recourse would have to be had to the diagnostic puncture.

Filarious lymphangitis has been mistaken for plague, but an examination of the blood for filaria would clear up the diagnosis.

Veldt sores and tic bites may cause inflammation of lymphatic glands. The condition of the patient distinguishes such cases.

Pestis minor has been referred to (p. 569).

Neuralgic pains in the groins are not uncommon among those engaged on plague work. They seem to be usually neurotic, but cause considerable anxiety.

(*b*) *Diseases without Glandular Swellings.—Puerperal fever* may be diagnosed instead of plague septicæmia. In plague, the fever comes on before delivery or abortion, and is almost invariably fatal. The absolute diagnosis of plague rests upon the bacteriological examination of the blood.

Septicœmia and pyœmia can only be differentiated from plague by bacteriological examination.

Smallpox may be confused with plague until the rash comes out.

Influenza, septicæmic and pneumonic plague may present great difficulty in diagnosis; the character of the pneumonia and nervous systems are similar in each. Examination of the blood and sputum is necessary.

Cerebro-spinal meningitis and plague both show meningeal symptoms, but in plague retraction of the head is not common. Meningitis may supervene in plague.

Malaria may be confused with plague. The character of the tongue is different; examination of the blood and the treatment clear up the diagnosis.

Typhoid fever may be diagnosed by Widal's reaction, the spots and other characters of the disease. In doubtful cases bacteriological examination of the blood should be employed. The onset is insidious in typhoid and sudden in plague. In plague the temperature rises suddenly.

Typhus, dengue, and relapsing fever should be differentiated from plague by examination of the blood, together with the signs of these diseases.

Lobar pneumonia may simulate plague pneumonia, but a bacteriological examination of the sputum and the characteristics of these diseases indicate the diagnosis.

8. PROGNOSIS.

Plague is a very fatal disease, the case mortality among European patients treated in hospital being about 35 per cent, and is much higher among native races.

The prognosis depends on (1) *the period of the outbreak.* Cases are milder at the beginning and end of an epidemic, but not invariably. (2) *On the type of the disease.* Pneumonic and septicæmic cases are generally fatal. (3) *On the age of the patient;* unfavourable in the very young and the aged. (4) *On the site of the bubo.* Cervical lesions are most fatal; this type is frequent in children. (5) *The race of the patient* has an influence. Most of the Asiatic races show a lack of resistance to the disease. (6) *Sex* has no influence except that if the patient is pregnant she usually aborts or is prematurely confined, with nearly always fatal results to the mother and child. (7) *The stamina of the patient* has an influence, though often absolutely healthy persons contract the disease and die in a few hours. (8)

Haffkine's prophylactic influences the disease greatly, rendering the type of the disease as a rule mild. (9) *Co-existing diseases,* such as tuberculosis, may make great advances in convalescence, and the patient may succumb to acute phthisis. (10) *Other points* to be noted are—the character of the heart and pulse; obstinate vomiting; early diarrhœa; brain symptoms, such as long-continued sleeplessness, delirium and coma; hæmorrhages; all these are bad signs. The presence of the bacillus in the blood points to septicæmia and approaching death.

If the patient survive the first week of his attack the prognosis becomes more favourable.

Early hospital treatment gives the patient his best chance of recovery.

9. TREATMENT.—(*a*) *Symptomatic,* (*b*) *Antitoxic*

(*a*) *Symptomatic treatment* is the chief line to be taken. The *general management* of the case consists in rest in bed, in the recumbent attitude, for at least ten to fourteen days, the patient being on no account permitted to get out of bed. A sufficient supply of nurses should be provided, as a patient during the acute stage should never be out of sight of an attendant. After ten to fourteen days the patient may get up gradually, the condition of the heart and pulse being carefully watched, and provided no complications arise. The patient should be kept in cool and well-ventilated surroundings. Every case should be treated in hospital, not only to control infection as far as possible, but also because of the importance of trained nursing and prompt medical assistance in the sudden emergencies which may at any moment arise.

As regards *the diet* it should be light and nourishing. Milk, beef-tea, soups, and beaten-up eggs are permissible while the temperature remains high. Then ordinary light diet should be given. In cases of obstinate vomiting, rectal feeding (peptonised milk 2 to 4 oz. in children, given four hourly) must be employed, the quantity being cautiously increased. If vomiting persists, and even water cannot be retained by the stomach, it is necessary to give "water-feeds" of 3 or 4 ounces, per rectum, about an hour before the milk-feeds. The rectum must be washed out with tepid water every twenty-four hours while this feeding is being carried on. The feeds are best given by a funnel and tubing with a soft catheter inserted in the rectum.

Stimulants, though frequently necessary, should not be exhibited without due cause. The chief symptom calling for stimulants is heart failure and continued high fever. Brandy, if necessary, should be administered by the mouth. In cases where vomiting is absent it is best given as egg-flip, provided the patient can retain and digest it. In cases of collapse, hot brandy and water, hot-bottles and blankets, are efficacious. Brandy should not be given per rectum unless absolutely necessary, for it is apt to set up irritation which may render rectal feeding impossible. In cases where vomiting is present champagne should be tried. Strychnine should be given by the mouth alone, or with digitalis as a cardiac stimulant, as indicated by the state of the pulse and heart. But its chief use lies in its hypodermic administration to cases suffering from cardiac depression or sudden heart failure. Here it may be given in doses of 5-10♏ every hour, or less frequently, but the patient should be watched carefully to see that no symptoms of poisoning occur. It is surprising, however, the toleration these cases have for strychnine. It is impossible to give definite instructions on this point as each case must be judged on its own merits, but strychnine is the sheet anchor of our treatment of plague. In septicæmic and pneumonic plague a few minims of this drug must be administered every few hours, hypodermically if necessary. Ammonium carbonate is an excellent stimulant, especially in pneumonic cases. Ether is very useful in sudden collapse on account of its prompt effect. The nurse must be instructed to give hypodermic injections of ether and strychnine promptly in cases of collapse, as any delay may be fatal.

Restlessness, sleeplessness, and continued high fever should be treated with cold sponging and packs, but in children restlessness is often found to be controlled by hot sponging. Phenacetin and antipyrin should not be used, but $\frac{1}{100}$ grain of hyoscine, or $\frac{1}{8}$ to $\frac{1}{4}$ grain of morphine, may be necessary in some cases.

Vomiting should be treated by hot applications, turpentine stupes, or a blister to the epigastrium. Hydrocyanic acid is frequently efficacious, and often sucking ice gives relief.

The bowels should be kept open by enemata rather than by drugs, but 5 to 10 grains of calomel, if necessary, should be given at the onset of the attack. *Diarrhœa* should be controlled by 10 grains of salol or a starch and opium enema.

The bubo should be treated with hot fomentations, lead and opium, or glycerine and belladonna applications to relieve pain, and should be treated, if it suppurates, on the ordinary lines of dealing with abscesses.

The eye, joint, and other surgical complications should be treated in the usual manner.

(*b*) *Antitoxic Treatment.*—With regard to the serum treatment of the disease the subcutaneous injection of *Yersin's serum* has not yet been proved to have served much curative purpose, possibly on account of cases not coming under treatment sufficiently early; possibly, also, the dosage has been sometimes insufficient, but 200 c.c. given subcutaneously have in some cases been found to be of benefit. More encouraging results have been obtained by the intravenous administration of 30 to 60 c.c. of the serum, and this may conveniently be injected into the veins on the dorsal aspect of the hand or the front of the wrist. If the serum be warmed the patient experiences little discomfort.

Lustig's serum has been used in India both subcutaneously (in doses of 200 to 2000 c.c.) and intravenously. It had little effect in septicæmic cases, but appeared to be of some service in bubonic cases with multiple buboes. It cannot, however, be regarded as of much assistance in serious cases. Although the serum treatment of the disease appears to be the only one which holds out much prospect of reducing the case mortality in plague, it must be admitted that as yet the value of the preparations available has not been sufficiently established.

10. Curative and Preventive Sera and Prophylactics

A number of sera and prophylactics have been prepared, and their use advocated by those who have discovered them. The value of some of them is based rather upon laboratory experiments than upon use on a large scale.

(1) *Yersin's serum* has received trial as a prophylactic agent; 10 c.c. are administered subcutaneously into the skin of the abdominal wall, giving an immunity for ten to fourteen days. To obtain further immunity it is necessary to repeat the injection at the end of each period of ten or fourteen days. The use of this serum is only to be recommended as a prophylactic in cases where it is desirable to rapidly immunise a person who has been exposed to infection. In the great majority of cases, as will be seen, Haffkine's prophylactic should be employed. Reference has already been made to the curative use of Yersin's serum.

Its mode of preparation is to inject living cultures of plague bacilli intravenously into a horse; the serum is obtained by bleeding the animal.

(2) *Lustig's serum* is obtained from the blood of horses immunised by the injection of a nucleo-proteid, which is prepared by treating plague cultures with 1 per cent caustic potash; after acidifying with dilute HCl the precipitate is filtered off, washed, and dried. The nucleo-proteid is stated to have prophylactic properties. The curative results of the serum have not been very promising in India.

(3) *Terni and Bandi's serum* is obtained by immunising animals with a vaccine prepared by intra-peritoneal injection of rabbits with plague bacilli; the peritoneal secretion is treated with "sea-salts" and heated for some hours at 60° C. I am not aware of the results of using this serum and vaccine on a large scale.

(4) *Haffkine's Prophylactic.*—In the preparation of his plague prophylactic Haffkine was led, from the results of his anticholera inoculation, "to treat the system with a combination of the actual bodies of the plague bacilli and of the concentrated products of their activity." Plague bacilli are cultivated in broth from the surface of which they are suspended as a stalactite growth from drops of clarified butter (*ghee*), or of cocoa-nut oil floating on its surface. The flasks containing the growth are periodically shaken, and the growth falls to the bottom, allowing a new crop of stalactites to grow from the surface. An increasing amount of toxine is also formed, secreted from the bacilli and accumulating in the broth. This process is continued for five or six weeks, when it is stopped, and the bacilli killed by exposing the flasks to 70° C. for one hour. The prophylactic is then ready for use after the dose for man has been determined. This has to be done by experiment for each brew of the prophylactic. The fluid is sealed up in vessels, after adding a small quantity of some antiseptic, and sent out for use. The usual dose is about 5 c.c. for an adult, and should be injected into the outer part of the upper arm. A few hours after inoculation, malaise, fever, and aching at the site of injection occur, followed by some prostration, together with redness and swelling of the upper-arm. These symptoms usually last about twenty-four hours, when the person inoculated resumes his normal health, though the local inflammation and swelling may persist for some days. Sometimes the reaction is somewhat more severe than has been indicated, and the patient may be some days before he recovers. Rarely abscesses occur, as with any other subcutaneous injection. The most convenient time for being inoculated is in the afternoon, say about 3 P.M.; about 8 P.M. constitutional symptoms occur, the patient passes an uncomfortable and restless night, feels more or less ill next day, which should be spent at rest. On the following day he is well enough to resume his ordinary duties in the majority of cases. A lead and opium application may be of service where there is much local reaction.

Immunity after inoculation, which is never absolute, is established in about ten days (though Haffkine and Bannerman put it at a much shorter period), and persists for a time which is not yet determined; it is at least six months, and probably longer. As the duration of an ordinary plague epidemic is not as a rule longer than this, the person inoculated has secured a large measure of immunity for that particular epidemic, though, if he wishes to continue protected, he must again undergo inoculation should there be recrudescence of the epidemic. The conclusions of the Indian Plague Commission upon this subject were:—

(1) Inoculation is harmless.

(2) When given in the incubative stage, *i.e.* before the signs of plague are apparent, it has in many cases the power of aborting the disease.

(3) Inoculation affords to all those inoculated a strong protection against attack by plague.

(4) In the few cases where inoculated people are attacked a very large proportion recover.

There is a difference of opinion held by many people as to the second of these conclusions, but it is supported by Bannerman, an authority on the subject. As to the first, third, and fourth of these conclusions, there can be no question of the accuracy of the statement of the Commission.

By again undergoing inoculation ten days after the first injection a greater amount of protection is secured.

(5) *Kitasato's prophylactic* is prepared from agar cultures of plague bacilli. Its inoculation effects are much milder than those of Haffkine's prophylactic. It has been used on a large scale in Formosa with excellent results, both with regard to reduction of the rates of incidence and of case mortality among the inoculated (*Journal Trop. Med.*, May 1st, 1902).

(6) *Calmette's vaccine* is obtained from cultures of the bacillus upon gelose. By

filtration and repeated washings the bacilli are obtained as free as possible from toxines. The dried bacilli constitute the vaccine, of which the value does not appear to have been tested on a large scale.

11. MEASURES TO BE TAKEN UPON THE OCCURRENCE OF AN OUTBREAK OF PLAGUE

1. *Administration*

The public health authorities of a place likely to become plague infected should plan out the details of the arrangements which will become necessary in the event of the arrival of epidemic plague.

A. *Measures in anticipation.*

(*a*) The provision and equipment of a plague hospital and of an ambulance department.

(*b*) The provision of reception houses for "contacts."

(*c*) Arrangements should be made for securing the services of an adequate medical and nursing staff should they be required.

(*d*) The details of the measures to be presently described should be considered, so that they may be ready to be set in motion at the outset of the epidemic.

(*e*) A campaign against rats and insanitary conditions should be at once instituted.

B. *Measures to be adopted at the outset of the epidemic.*

(*a*) The staff of the plague hospital should come on duty and be suitably augmented as required. This includes medical officers, nurses, ward attendants, porters, etc. The menial staff, especially among native races, should be recruited from recovered patients, after the first few weeks of the epidemic. Every plague case should be removed to hospital.

(*b*) The reception houses must be opened.

(*c*) Disinfection gangs must be formed, each in charge of a reliable "ganger," and the whole under some responsible person.

(*d*) The M.O.H. would in this country be in charge of the plague administration, but it may be necessary, especially abroad, to appoint a medical officer in charge of the plague administration.

(*e*) The locality should be divided into districts of a suitable size, each in charge of a medical officer (D.M.O.) with a staff of sanitary inspectors. The D.M.O.s should visit suspicious cases and act as medical referees in conjunction with the medical attendant (if any) in charge of the case. It is convenient, especially in the colonies, to place the D.M.O.s in sanitary charge of their districts, under the senior medical officer of the plague administration.

(*f*) A bacteriologist is necessary.

(*g*) In some of the colonies an advisory plague board, composed of men of influence in the locality, has been found of use. This board should not have any executive functions.

(*h*) The plague staff should all be inoculated with Haffkine's prophylactic, and this should be made a condition of employment.

(*i*) All persons employed on plague duty should be segregated and provided with housing accommodation by the plague administration.

2. *General Measures to be adopted.*

(*a*) *Public co-operation* must be secured as far as possible. It usually happens that the inhabitants of a town attacked by plague are divided into two parties—those who are panic stricken at the advent of the disease, and those who scout the idea of its presence. The former can be soothed, and some of the latter perhaps convinced by holding public meetings addressed by prominent men in whom they have confidence, also by advertisements, posters, leaflets, and articles in the press. These should advise on preventive measures necessary, and point out the manner in which plague may be contracted and spread. The destruction of rats and a campaign against insanitation should be urged. The importance of early notification, both from the patient's and the public's point of view, should be represented, together with the advisability of seeking early medical assistance in suspicious cases.

(*b*) *Preventive inoculation by Haffkine's prophylactic* must be prominently laid before the public. Its acceptance will largely depend on the confidence with which the people regard the medical officer who advises it, and also upon the light in which people regard vaccines. We are compelled to admit that this prophylactic is less preventive against plague than vaccination is against small-pox, but the extent and virulence of the epidemic may be sufficient to overcome conscientious objection. Persons exposed to infection by living or working in infected localities should be specially urged to protect themselves by inoculation. The statement of the Indian Plague Commission already quoted should be made public, or some such notice as the following should be widely distributed :—

"PLAGUE PREVENTIVE INOCULATION

"The public are strongly urged to submit themselves to the preventive inoculation against plague, whereby they will receive a very great amount of protection against the disease. It has been proved of great benefit in India, Australia, and South Africa, where among the small proportion of the inoculated who contracted plague the disease has usually taken a mild course. The operation is followed by some feverish disturbance which passes off in a few hours, and by some swelling of the upper part of the arm, which should be kept at rest for a day or two. Persons may be inoculated by their own medical attendant, or at the following places by the officers provided for the purpose." . . .

(*c*) *Sanitation*.—A general campaign must be conducted against insanitary conditions, especially against those likely to encourage the presence of rats near houses. Overcrowding should be abated as far as possible, and filthy houses cleansed. Special attention should be devoted to such occupations as rag picking, old clothes selling, and the like. The exportation of rags must be prohibited.

(*d*) *Medical Supervision of Contacts*.—In some places it has been customary to remove contacts from their houses, and to place them in an enclosure under a guard for ten or twelve days. During this period they are daily inspected by a medical officer, and are not allowed to mix with the outer world. This system has been adopted, not only among natives where it is often inevitable, but also in the cases of Europeans. It imposes great hardships in many instances, and is not a reasonable plague preventive measure where it can be avoided. The idea is to daily inspect every person who has been exposed to plague infection until the expiration of a liberal incubative period. Provided these persons have been compelled to evacuate their houses till these have been disinfected, and provided the clothes they are wearing are also disinfected, I can see no objection to their mixing with the outer world during the period they are under observation. The only necessity is that they should not evade medical inspection, and this could be easily guaranteed upon their own undertaking, in the case of the respectable, and others should be asked to find some surety for their appearance at the daily inspection. In this way a man goes to work from the reception house to which he has been removed, and his mode of life is as little inconvenienced as possible. There is a difficulty in carrying out such a scheme among native races, but every effort should be made to avoid compulsory segregation of contacts, which has been one of the great sources of public opposition to plague measures.

(*e*) *Evacuation of Infected Premises*.—All premises, *whether infected by rat or man*, should be forthwith evacuated and disinfected. A camp of tents or other dwellings should be provided, into which the inhabitants of blocks of buildings should be sent while their houses are being disinfected. Contacts of cases should be sent to reception houses or camps of this nature and daily inspected. It is essential to remove every plague case, except those who are practically moribund, to hospital.

(*f*) *Disinfection; Disinfection of Infected Premises*.—Infected premises, being defined as those infected by man or rats, must after evacuation be disinfected. This cannot be done whilst the people are in their houses. They can be despatched to the reception house to undergo personal disinfection, and remain there or with friends till their houses are ready for them. After removal of the case and contacts the house should be taken in charge by the plague authorities and locked till the disinfecting gang arrive. It should then be subjected to fumigation by burning sulphur, liquefied SO_2, or by some efficient type of formalin lamp. After twelve hours the house should be opened, and after an inventory is taken, the interior of the dwelling cleansed by washing and spraying the walls and ceilings with 2 per cent formalin solution or corrosive sublimate. A useful stock solution is—Corrosive sublimate, 4 oz.; hydrochloric acid, 1 pint; water to 1 Winchester quart; colour with litmus. For use, add half a bottle to 6 gallons of water, or 8 fluid oz. to 1 gallon of water. This must be mixed in wooden vessels. The furniture should be sprayed with the 2 per cent formalin solution.

A certain number of articles, such as filthy rags and blankets, must be burnt, and such things as bedding, clothes, etc. sent to the steam disinfector. After the house is disinfected it must be exposed to the influence of sunlight and fresh air. The point in which the disinfection of a plague house differs from that of any other infective disease is that it is absolutely necessary to remove all floors, skirtings, false ceilings, and so on, if there are any signs of rats about the house. This causes considerable expense and takes time, but it has to be done thoroughly. Any dead rats found must be at once cremated, and the infected area saturated with disinfectants, such as Jeye's fluid (2 oz. to 1 gallon of water). Rat runs must be followed, dug up, and obliterated. Broken glass, tar, and crude carbolic acid (Calvert's No. 4) are useful in this connection. Basements of houses, and the floors of stores of grain and forage, should be concreted and made as rat-proof as possible.

All out-buildings, cellars, etc. should be lime washed (unslaked lime, ½ lb. to 3 gallons of water), and the opportunity should be seized of requesting the landlord, or by serving him with the proper notices, to make any necessary alterations to the house to put it in a satisfactory sanitary condition.

As regards disinfection of native huts in South Africa, India, and elsewhere, mud floors should be disinfected with phenyle (1 to 50) or acid corrosive sublimate ($HgCl_2$ 1 part, strong HCl 2 parts, water to 500 parts). In many cases it is possible to burn down the huts. Impermeable floors should be disinfected with phenyle (1 to 100) or acid perchloride of mercury (1 to 1000).

Disinfection of clothes must be effected by steam where possible, or by destroying them by fire if worthless. If this cannot be done they should be fumigated, boiled, immersed in disinfectants, exposed to sunlight, or disinfected by the best method available.

Disinfection of ships is best effected by sulphur fumigation, as described under "destruction of rats on board ship" (page 583). Infected quarters should be fumigated, and the woodwork washed down with acid corrosive sublimate solution, the bedding, etc. being removed, if possible, to a steam disinfector.

Disposal of the Dead.—If death occurs at home, the body must be at once handed over to the plague authorities, wrapped by them in a sheet soaked in corrosive sublimate, placed in a coffin, screwed down, and conveyed to the place of burial, which must be adjacent to the plague hospital. Wakes must be strictly prohibited, and the aid of the Roman Catholic clergy should be sought for this purpose. Cremation, when possible, should be employed.

Disposal of Excreta and Discharges.—These should be received into 5 per cent carbolic acid solution and disposed of by burning in an incinerator, or by heating them to 100° C. in a large iron pot. After complete chemical disinfection they may be disposed of by burial or by the sewerage system.

(*g*) *Inspection of Travellers by Rail.*—This has been conducted in many places abroad, and no one has been permitted to travel until they had received a certificate that they presented no signs of plague. It has prevented many infected natives in India from travelling. In this country some system of notification of departure from an infected locality might perhaps be usefully employed, and sent to the local authority at the passenger's destination.

3. *Destruction of Rats.*—(*a*) On land; (*b*) On board ship.

(*a*) *On Land.*—The various methods of clearing premises of rats, such as employing professional rat-catchers with ferrets and dogs, or laying down poison and traps, must be adopted. It must be remembered that ferrets are liable to contract plague. Keeping a mongoose on the premises has been highly recommended, especially in places where the mongoose cannot readily escape. Poisoned rats cause a certain amount of nuisance, but the smell can be traced, and by taking up the floors and so forth their haunts can be discovered and the rat runs obliterated. When premises have been cleared of rats the necessary steps must be taken to prevent them gaining entrance again, by stopping up or wiring any apertures which might serve as a run, and by concreting where necessary, especially in stores and basements. Doors must be made to fit accurately, and to be bound in iron at the bottom if possible, to prevent rats gnawing their road in. The process, therefore, consists of two actions : (1) a simultaneous campaign against rats all over a town ; (2) making premises rat proof, after they have been cleared of rodents. Unless the public take the matter up little can be done.

Danysz's Method.—J. Danysz, chef de laboratorie à l'Institut Pasteur, has exalted the virulence of an organism of the *coli* group, which, under certain conditions, causes among rats and mice an epidemic disease which is not transmissible to man. This organism, morphologically identical with the *Bacillus typhi murium* (Löffler) and with Gaetner's bacillus, can be made pathogenic for all varieties of rats with some difficulty. Danysz has described the method by which he has done this in the *Annales de l'Institut Pasteur* for April 1900, one feature being the growth of the culture in collodion capsules in the peritoneal cavity of the species of rat whose extermination is being sought. The practical application of Danysz's virus is to spread growths of the bacillus on bread and to place it where rats frequent. An epidemic is claimed to be set up, which, after three or four passages through these rodents finally dies out. The method has its limitations, and has been of little value in some places where it has been employed. Danysz recommends that it should be used in spring and autumn, so that the young rats, which are more susceptible, should be destroyed. It is also important to keep on laying down fresh cultures to replace those whose virulence has died out. Danysz is of opinion that by systematic attack for a season or two on the young susceptible rats the complete extirpation of these animals may be secured. Klein and Williams, working on this bacillus both in the laboratory and on a large scale, arrived at negative conclusions as to its value (*Lancet*, Aug. 17, 1901). The method is far from being perfected or certain in operation, and much further laboratory research is necessary, coupled with experiments on a large scale. It would seem to be necessary to exalt the virulence of the organism locally, by experiment, so that it should become capable of destroying the race of rats which infest the neighbourhood in which it has to be employed.

(*b*) *On board ship* rats can only be destroyed to any great extent when the vessel is *empty.* Then by sulphur fumigation of the compartments a great proportion of the rats can be destroyed. In Australia there is an inter-colonial agreement under which vessels are compelled to produce a certificate of fumigation given by officials provided for the purpose, and without which they are liable to detention. This method is stated not to unduly interfere with trade, and to be in practice not difficult to secure. This answers some of the great objections to the compulsory destruction of ship rats. It is obvious that the only way to prevent plague rats gaining access to an uninfected port is to destroy, systematically, rats, healthy or otherwise, on board every ship, as far as possible. It is further necessary, if the ship is to be kept rat free, or as nearly so as possible, to keep the vessel moored some distance off the dock, to hoist in gangways at night, and to provide guards on the ropes and hawsers, and by tarring them, to prevent communication of ship and shore rats. It is of importance to recognise that rats enter and leave ships in cargo such as forage and skeleton crates, even when the vessel is lying out some way from the shore, and cargo is brought off in lighters, so that fumigation of the vessel when empty is necessary at the end of each voyage.

The generation of CO_2 in the holds of ships has been advocated, but from the lack of penetrating power of this heavy gas the method has not attained much success. The method of sulphur disinfection which appears to work best in practice is that produced by the *Clayton machine* (of the Clayton Fire Extinguishing and Ventilation Company) which consists of a special apparatus. It drives the gas produced by the combustion of sulphur into the lower parts of the holds of ships, made as nearly air-tight as possible, while air is extracted from the upper part till the whole of the air space contains about 10 per cent SO_2. The air extracted is passed over the heated sulphur in the furnace. The apparatus may be placed on deck or on a barge alongside, so there is no danger of causing a fire in the hold. The quantity of sulphur used is 1 lb per 400 cubic feet of space, and the cost is about 20s. per 100 tons gross register (*Public Health*, March 1902). This "Clayton gas" appears to owe a considerable amount of its efficiency to the presence of some SO_3 which is formed, in addition to the SO_2, by the high temperature in the furnace. The results obtained are vastly superior to those involving the use of pure SO_2. It is stated that less than 5 per cent Clayton gas is as sufficient as 15 per cent pure SO_2 in its power of destroying rats and other vermin. The Clayton gas has, it is said, no appreciable action upon coloured materials, foodstuffs, paints, or dry metals, except in a moist atmosphere. Further, 8 per cent of this gas is stated to rapidly extinguish burning materials. At Cardiff recently it was found that by this method rats placed in cages at the bottom of the hold were killed almost immediately, and those about 6 feet below the level of the deck within three hours' exposure. As far as disinfection went, liquid cultures of plague, cholera, and typhoid, soaked in strips of fabric, were killed after an exposure of twelve hours, but anthrax and one of three cultures of staphylococcus pyogenes aureus remained alive (*Lancet*, June 21 and July 19, 1902).

4. *Measures Employed in excluding Plague from a Country*

(*a*) *International Notification.*—This is done among the signatories of the Venice Convention of 1897, which includes the leading European powers, but does not include Portugal, Servia, Turkey, and Greece. Notification takes place upon the occurrence of epidemic plague in man, but no steps are taken upon the outbreak of the disease in rats, an omission of considerable importance in the light of our present knowledge.

(*b*) *Arrest of Infected Persons and Things.*—Under the cholera, yellow fever, and plague order of the L.G.B. (England) 1896, and of the L.G.B. (Scotland) 1898, all vessels from infected ports are boarded by the port M.O.H. on arrival in this country, and the crews and passengers are medically inspected. If all are well on board, or no suspicious case or death has occurred on the voyage, the vessel is then at liberty to land cargo and passengers. If it is infected the vessel is required to be moored at a certain fixed place, and the cases or "suspects" removed to hospital. It is to be noted that a "suspect" cannot be detained longer than two days, unless a definite diagnosis of plague is arrived at. In some cases this is too short a time to arrive at a definite diagnosis. The other persons on the vessel are allowed to land after furnishing their names and addresses, this information being forwarded to the respective sanitary authorities at the destinations. Clothing likely to have been infected, and the infected parts of the ship, are disinfected under the orders of the M.O.H. Where a ship is not ascertained or certified to be infected, but has passengers on board who are in a filthy or otherwise unwholesome condition, *or* has come from an infected place, the M.O.H. may, if in his opinion it is desirable, give a certificate that these persons be not allowed to land till they have satisfied him as to their names, places of destination, and addresses at such places. The M.O.H. has therefore power to detain such persons for inquiries, and part of such time must be utilised in cleansing their persons and possessions.

(*c*) *Destruction of Rats afloat.*—The importance of this measure, and the way in which it may be done, has been already referred to. The Local Government Board of England have issued a special memorandum on ship-borne plague and rats, dated April 1901, advising local authorities to destroy rats in infected and suspected ships, to keep them moored off the shore, and to take the same precautions in case of rat mortality in vessels from infected ports. They also *advise* disinfection of ships with infected rats, and that the destruction of all rats on ships and shore should be attempted. This memorandum is of the nature of advice rather than a regulation.

In Bristol and other large ports the following methods are in use :—

(1) A list of infected ports is prepared by the Medical Officer of Health and kept up to date.

(2) An infected port is kept on the list for three months after official clearance.

(3) Vessels, especially grain and cotton-seed boats, from infected or suspected ports, are upon arrival treated as "suspects," moored six feet off the shore, with cables guarded and gangways up at night. Day and night watchmen are employed to prevent rats gaining the shore.

Dr. Davies, in an article "Exclusion and Control of Plague," (*Public Health*, March 1902) puts the matter in a nutshell when he states: "The present policy of allowing the approach of rat-infected ships, and then attempting to prevent the rats coming ashore, is surely attacking the evil at the wrong end. If possible, the obviously correct method would be to insist upon the destruction of all rats in ships when *empty*, and upon the subsequent observance of precautions to prevent the entry of more rats when loading at infected or other ports."

LITERATURE.—The following are the principal works consulted :—**Historical**: HIRSCH. *Handbook of Geographical and Historical Pathology.*—*Reports of Med. Officer of L.G.B.* (*England*) 1898-99, 1899-1900, and special plague volume, 1902. **General**: J. A. THOMPSON. *Report on Plague in Sydney.*—*Report of Indian Plague Commission.*—J. V. MONTENEGRO'S *Bubonic Plague.*—J. CANTLIE'S *Plague.*—B. SCHEUBE'S art. "Plague," in *Die Krankheiten der Warmen Länder.*

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